VILLAGE OF RUIDOSO WATER SYSTEM

SOURCE WATER PROTECTION PLAN

Prepared by the Village of Ruidoso
In Conjunction with the New Mexico Environment Department
Drinking Water Bureau

March 27, 2014

This page was intentionally left blank.

VILLAGE OF RUIDOSO
SOURCE WATER PROTECTION PLAN

March 27, 2014

Approved by:

Debi Lee

Debi Lee
Village Administrator
Village of Ruidoso

March 27, 2014

Dennis McQuillan

Dennis McQuillan
New Mexico Environment Department
Drinking Water Bureau
Source Water Protection Program Manager

March 27, 2014

Table of Contents

I. Source Water Protection Program Background

Access to clean, safe drinking water is a key component to a healthy and viable community. Protecting sources of drinking water from contamination and depletion can prevent adverse human health, ecological and economic consequences.

Source Water Protection is a voluntary program, created by Congress in the 1996 amendments to the Safe Drinking Water Act, to encourage partnerships between states and public water systems to protect sources of water supply. The U.S. Environmental Protection Agency provides guidance and funding to help states develop partnerships with public water system to protect water sources from contamination and depletion, and to develop contingency plans in the event that water sources dry up or become contaminated. The New Mexico Environment Department (NMED) Drinking Water Bureau and the Village of Ruidoso have partnered to develop this Source Water Protection Plan. In addition to establishing measures to monitor and protect Ruidoso's sources of drinking water, this Plan also assembles valuable information about Ruidoso's hydrogeology and water sources into a single document that can serve as an important reference in the future.

II. Source Water Protection Team

The following Team assembled relevant technical information and drafted this Source Water Protection Plan.

Source Water Protection Team Members

Name	Affiliation	Email
Randy Koehn	Village of Ruidoso	randykoehn@ruidoso-nm.gov
Debbi Lee	Village of Ruidoso	debilee@ruidoso-nm.gov
J.R. Baumann	Village of Ruidoso	jrbaumann@ruidoso-nm.gov
Dennis McQuillan	NMED	dennis.mcquillan@state.nm.us
John Pijawka	NMED	john.pijawka@state.nm.us

The Team hosted a workshop on February 12, 2014 to inform the community of the process to develop a Source Water Protection Plan and to obtain public input on water supply concerns and recommendations on how to protect water sources. The following concerns and recommendations were provided during the February 12, 2014 public meeting:

- Efforts to replenish groundwater resources should be implemented.

- The Village needs additional funding to protect its water sources and to improve infrastructure.
- Additional effort towards public education on water issues would be beneficial.
- Concerns were expressed that the ongoing severe drought should be taken into consideration with regard to New Mexico's water debt to Texas. More specifically, the delivery of prescribed amounts of water to Texas, regardless of drought conditions and decreased water availability, may not be fair to New Mexico.
- Treated wastewater should be reused to the extent safe and practical.
- The installation of rooftop precipitation collection systems and storage cisterns should be encouraged for both residential and commercial buildings.
- Private domestic water wells should be monitored for water level and water quality.
- The Source Water Protection Planning process should be expanded to the County level to include additional public and private water systems and stakeholders.

The Source Water Protection Team greatly appreciates the thoughtful and constructive suggestions that were made during the public workshop. To the extent practical, these recommendations are incorporated into Section VI of this Plan.

III. Village of Ruidoso Water System

The Ruidoso Water System (Public Water System # NM3513114) in Lincoln County, New Mexico serves approximately 10800 persons in residential connections. Water sources include a combination of stream diversions, reservoirs and six active wells (Figure 1). Other wells are used for irrigation only or are inactive. Individual water sources are described in more detail in Appendices A.1 (surface water sources) and A.2 (groundwater sources). Well depths, water bearing rock formations and sustainable production capacities for individual supply wells are listed in Table 1. When flow in the Rio Ruidoso reaches levels specified by the Office of the State Engineer, the Village is authorized to pump water into Grindstone Reservoir from the Upper Canyon and Two Rivers Diversions (Figure 1). The Village produced approximately 584 million gallons of water in 2013, and 676 million gallons in 2012. Water use throughout the year is heavily impacted by part-time seasonal populations. Water rights issues in this region can be complicated and controversial, sometimes resulting in administrative appeals and litigation.

Table 1. Sustainable Production Capacities for Water Supply Wells. gpm, gallons per minute

Well	Well Depth (feet)	Water Bearing Rock	Capacity (gpm)
Alto #1			170
Brown			110
Cherokee	200	Yeso Formation	600

Green (old)			175
Green (new)	220	Volcanic (basalt)	220
High School	500	Permian sedimentary	300
Hollywood	254	Yeso Formation	700
North Fork #1	785	Volcanic (basalt and felsite)	550
North Fork #2			200
North Fork #3	796	Volcanic (basalt and felsite)	300
North Fork #4	599	Volcanic (basalt and felsite)	450

Ruidoso has used four surface water treatment plants:

- Plant #1 is located near the Rio Ruidoso upper canyon diversion and has been converted to a booster station (Figure 1).
- Plant #2 no longer exists but had been located on Hull Drive and received water from the Eagle Creek diversion (Figure 1).
- Plant #3 is operational and located south of Alto Reservoir at 103 Via Aguila (Figure 1).
- Plant #4 is operational and located just below Grindstone Reservoir at 500 Resort Drive (Figure 1).

IV. Geology and Hydrology

The Geology of the Ruidoso area has been described by Hall (1964), Kelly and Thompson (1964), and Rawlings (2008). Ruidoso is located along the southeastern flank of Sierra Blanca, a volcanic component of the Sacramento Mountains. Sierra Blanca consists of intrusive and extrusive volcanic rocks (shown in pink on Figure 2). East of the volcanic rocks is a faulted sequence of sedimentary rocks that underlie the central and eastern areas of Ruidoso (Figure 2). The sedimentary rocks consist of sandstone, siltstone, limestone, shale, coal and evaporites. A fault zone, with displacement down to the west, trends in a north-south direction through the central Ruidoso area (Figure 2). Relatively thin layers of alluvium have been deposited in canyon bottoms of the area.

Surface Water

The Village of Ruidoso is located within the Rio Ruidoso subwatershed of the Arroyo Hondo watershed (NMED, 2006). The Rio Ruidoso, and tributary streams Carrizo Creek and Eagle Creek, contain water derived from rain, snowmelt and, in some areas, groundwater inflow and/or wastewater. Surface water used for water supply in the region contains low mineral content and meets the secondary Maximum Contaminant Levels (MCLs) established by the U.S. Environmental Protection Agency for sulfate and total dissolved solids (Table 2).

Surface-water hydrographs are in Appendix B. The U.S. Geological Survey monitors stream flow in Eagle Creek below the South Fork near Alto, and in the Rio Ruidoso at Hollywood (USGS

Water Watch). The Hollywood gaging station is used to determine when stream flow attains the level set by the Office of the State Engineer to allow the Village to divert water from the Rio Ruidoso (Upper Canyon) and Two Rivers locations into Grindstone Reservoir. The hydrographs show annual high flow/flooding events that often occur in the late summer or fall.

Table 2. Surface Water Geochemistry Examples. MCL, maximum contaminant level. ND, not detected. NT, not tested. SC, specific conductance. TDS, total dissolved solids. MCLs for fluoride, $NO_3 + NO_2$, arsenic and uranium are enforceable human health standards. MCLs for chloride, sulfate, TDS and pH are non-enforceable recommended limits for the aesthetic qualities of drinking water.

	MCL	Eagle Creek	Rio Ruidoso	Bonito Lake
Calcium, mg/L		40	39	52
Magnesium, mg/L		8	7	11
Sodium, mg/L		12	14	12
Potassium, mg/L		1	1	1
Chloride, mg/L	250	13	14	14
Sulfate, mg/L	250	70	24	108
Bicarbonate, mg/L		77	76	90
Fluoride, mg/L	4	0.5	0.16	0.22
$NO_3 + NO_2$ as N, mg/L	10	0	NT	0.5
Arsenic, ug/L	10	NT	0	NT
Uranium, ug/L	30	NT	NT	NT
SC, µmho/cm		330	306	399
TDS, mg/L	500	230	210	298
pH, units	6.5-8.5	NT	7.96	NT

Figure 1. Village of Ruidoso Water Sources.

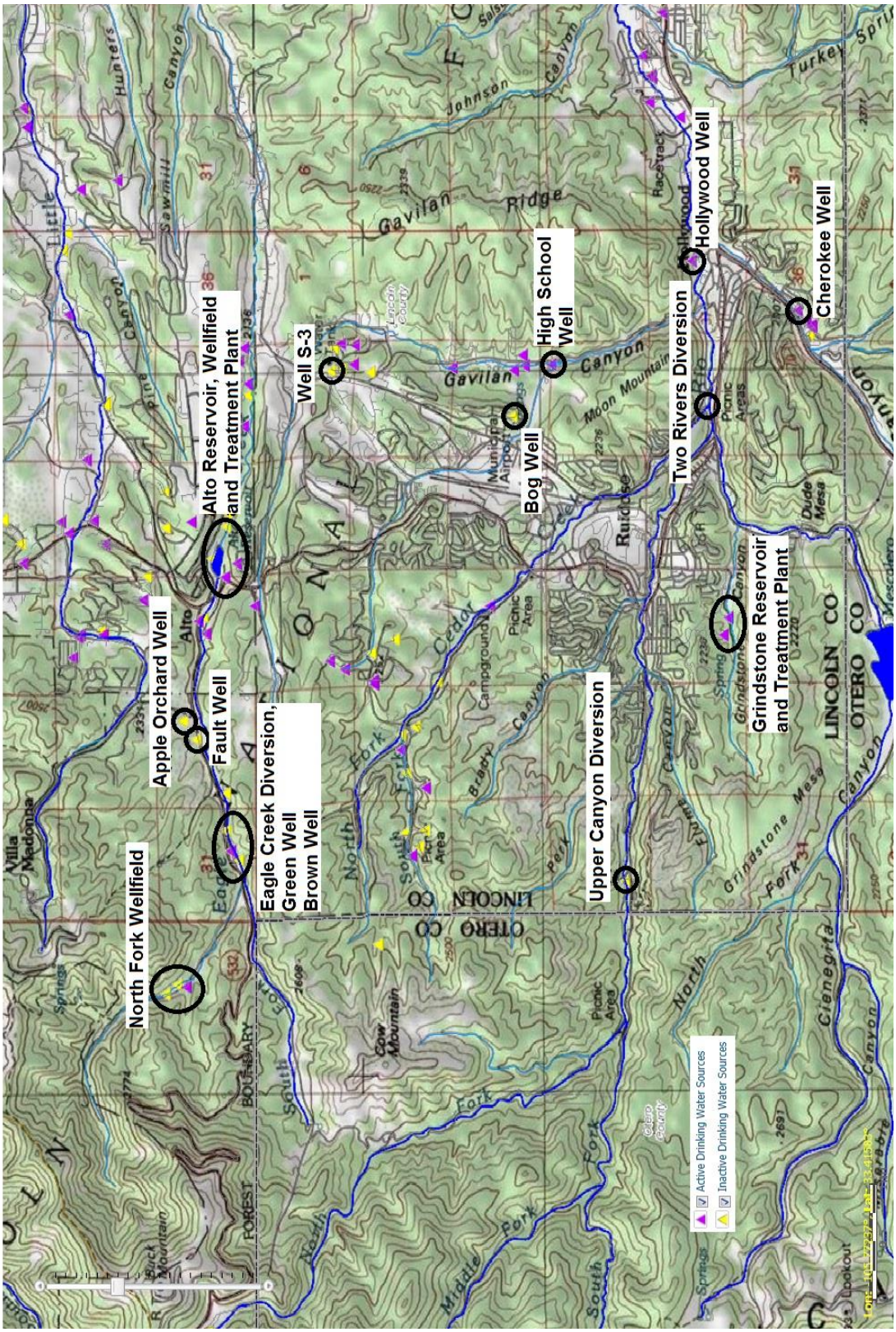
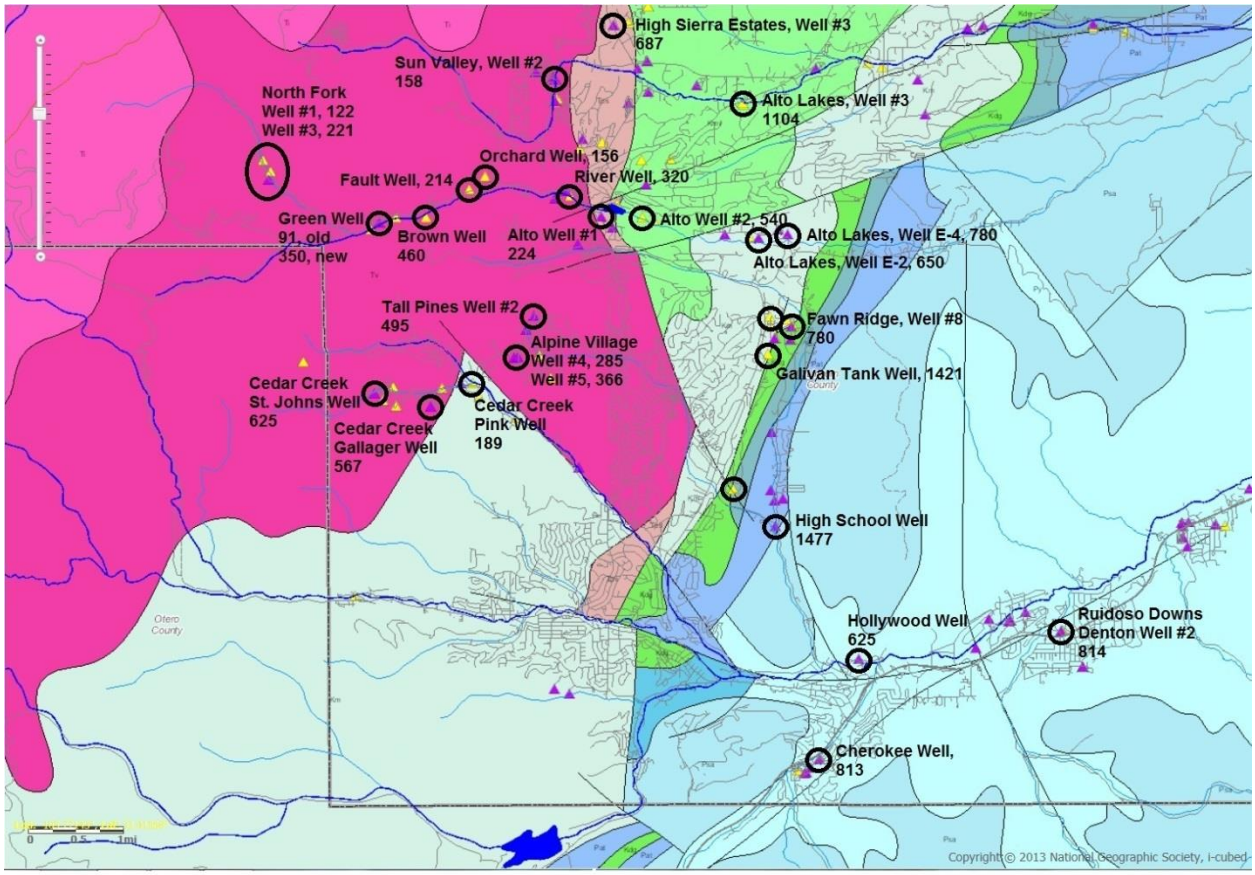


Figure 2. Geologic Map with Groundwater Sulfate Concentrations (mg/L). Base map is from the NMED Source Water Protection Atlas using a 1:500,000 scale state geologic map.



Volcanic intrusive rocks, Tertiary
Volcanic rocks, undifferentiated, Tertiary
Cub Mountain Formation, basin fill, Tertiary
Mesa Verde Group, sandstone, shale, Cretaceous
Mancos Shale, Cretaceous
Dakota Group, sandstone, shale, Cretaceous
Artesia Group, sandstone, limestone, Permian
San Andres Formation, limestone, dolomite, Permian
Yeso Formation, sandstone, siltstone, anhydrite, gypsum, halite, Permian

Geology and Groundwater Sulfate (mg/L) Ruidoso and Vicinity

Active Drinking Water Sources
Inactive Drinking Water Sources

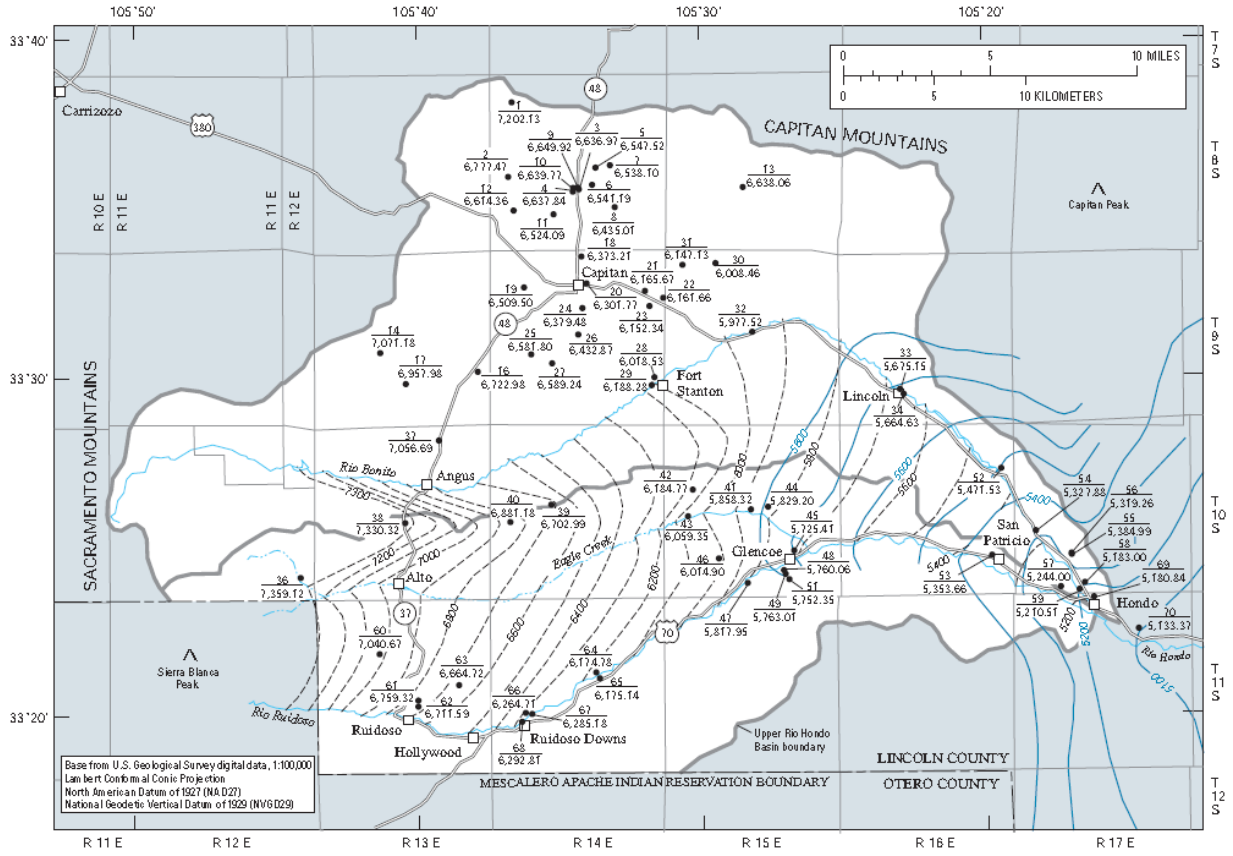
Groundwater

Groundwater occurs in the volcanic and sedimentary rocks and in the alluvium. In the Ruidoso area, the regional direction of groundwater flow is towards the east-southeast (Figure 3).

Hydrographs for wells in the Ruidoso area are contained in Appendix B. Aquifer water-level monitoring in the Ruidoso area is conducted by both the Village and by the U.S. Geological Survey (USGS). The Village monitors water levels in its supply wells and has prepared hydrographs showing water levels over time. The Village also performed a pump test on the Green replacement well that was drilled in 2007 (Miller et al., 2007). The USGS monitors water levels in 48 wells in Lincoln County (Appendix B), many of which are in the Ruidoso area, and hydrographs can be downloaded from the USGS (Groundwater Watch) website. The long-term water-level declines in hydrographs for the Green Well, North Fork Well #3, and Well 11S.13E.23.22321 (Appendix B) may be consistent with groundwater depletion. Hydrographs for other wells, however, show significant declines during 2012-13, followed by a sharp rise in water level after the heavy rains that occurred in the late summer of 2013.

Natural groundwater quality in the region varies widely depending on the geology of the aquifer. Wells drilled into the volcanic rocks, such as the North Fork wells, typically produce water of the highest chemical quality and meet all primary and secondary MCLs (Figure 2, Table 3.A). Minerals in volcanic rocks dissolve relatively slowly into groundwater. The sedimentary rocks, however, often contain naturally occurring minerals, like gypsum, that dissolve more rapidly into groundwater. Wells drilled into sedimentary rocks (Figure 2, Table 3.B) often produce water with high concentrations of natural minerals, such as sulfate and total dissolved solids, that exceed secondary MCLs and can impair the aesthetic qualities of drinking water.

Figure 3. Groundwater Level Altitudes and Contours. From Donohoe (2004).



EXPLANATION

Water-level contours published in Mourant, 1963—Contour interval 100 feet. Datum is NGVD29

Water-level contours based on March 2003 data—Dashed where approximately located. Contour interval 100 feet. Water levels measured north of Rio Bonito were not contoured because the area is geologically and structurally complex. Datum is NGVD29

Well

68 **Well identifier (table 1)**

6,292.81 **Water-level altitude, March 2003**

Table 3. Groundwater Geochemistry Examples. MCL, maximum contaminant level. ND, not detected. NT, not tested. SC, specific conductance. TDS, total dissolved solids. MCLs for fluoride, $NO_3 + NO_2$, arsenic and uranium are enforceable human health standards. MCLs for chloride, sulfate, TDS and pH are non-enforceable recommended limits for the aesthetic qualities of drinking water.

Table 3.A. Wells Drilled in Volcanic Rock.

	MCL	North Fork Well #1	Apple Orchard Well	Green Well (old)	Sun Valley Well #2
Calcium, mg/L		NT	64	NT	126
Magnesium, mg/L		9	14	17	17
Sodium, mg/L		23	84	32	33
Potassium, mg/L		5	1	5	1
Chloride, mg/L	250	16	29	58	26
Sulfate, mg/L	250	85	166	91	158
Bicarbonate, mg/L		107	221	222	260
Fluoride, mg/L	4	1.85	NT	0.6	NT
$NO_3 + NO_2$ as N, mg/L	10	0	0	0.1	NT
Arsenic, ug/L	10	0	0	0	0.0003
Uranium, ug/L	30	NT	NT	NT	1
SC, µmho/cm		418	733	709	785
TDS, mg/L	500	258	489	432	493
pH, units	6.5-8.5	7.89	7.72	7.74	7.62

Table 3.B. Wells Drilled in Permian to Cretaceous Sedimentary Rock.

	MCL	Cherokee Well	Hollywood Well	High School Well	High Sierra Well #3
Calcium, mg/L		NT		589	264
Magnesium, mg/L		NT	75	96	80
Sodium, mg/L		53	72	67	80
Potassium, mg/L		NT	3	3	2
Chloride, mg/L	250	NT	148	NT	251
Sulfate, mg/L	250	1000	423	1477	687
Bicarbonate, mg/L		NT	253	200	221
Fluoride, mg/L	4	0.7	0.5	NT	0.4
$NO_3 + NO_2$ as N, mg/L	10	NT	NT	NT	0.6
Arsenic, ug/L	10	0	0	NT	0
Uranium, ug/L	30	NT	NT	NT	NT
SC, µmho/cm		NT	1980	2979	2270
TDS, mg/L	500	NT	1447	2526	1588
pH, units	6.5-8.5	NT	7.25	7.00	7.14

V. Source Water Protection Areas and Assessment of Potential Contamination Sources

Source Water Assessment Areas are defined for each water source in Appendices A.1 (surface water sources) and A.2 (groundwater sources).

Surface Water

Intensive stream surveys conducted by the NMED Surface Water Quality Bureau (NMED 2006) identified the following impairments:

- Carrizo Creek – fecal coliform bacteria
- Eagle Creek – low flow alteration
- Rio Ruidoso – nutrients, turbidity and temperature

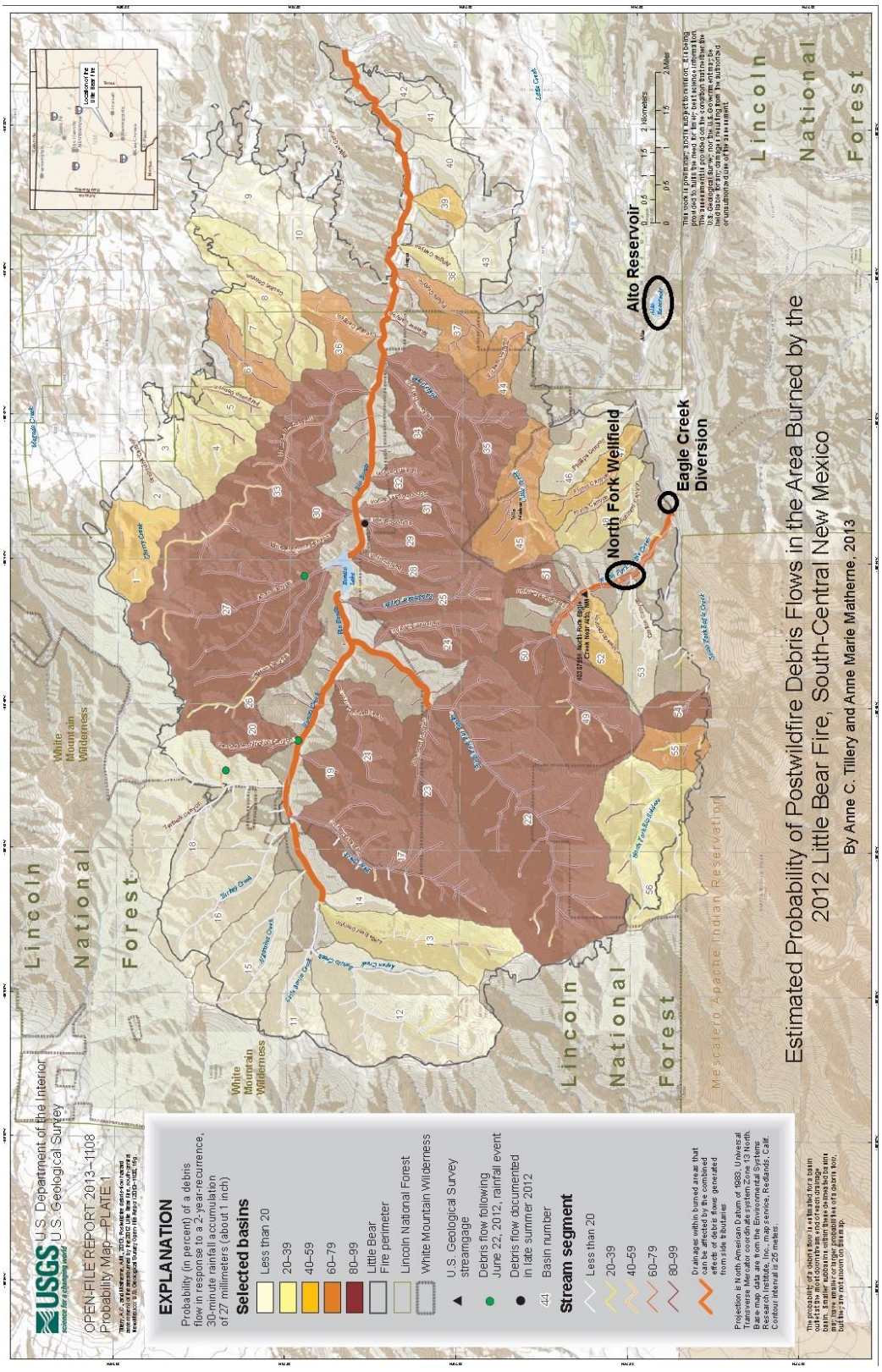
Potential sources of impairment included municipal and domestic wastewater treatment systems, rangeland grazing, site clearance, stream bank modification/destabilization, and loss of riparian habitat. Nutrient imbalances have caused excessive growth of filamentous algae in the Rio Ruidoso in the past (Figure 4). These surveys were used to establish Total Maximum Daily Loads (TMDLs) for the affected streams (NMED, 2006).

The Eagle Creek watershed was heavily damaged by the Little Bear Wildfire (Figure 5). Runoff from the burn scar has caused the use of the Eagle Creek Diversion and Alto Reservoir as sources of drinking water for the Village of Ruidoso to be temporarily suspended. The Eagle Creek Diversion is close to an area that may be at risk of post-fire debris flow (Figure 5).

The water level in Grindstone Reservoir is approximately 52 feet below the elevation of the spillway (Appendix A.1). At this low level, water diverted from the reservoir can contain high concentrations of turbidity, iron and manganese originating from anaerobic sediment at the bottom of the lake. These constituents can cause problems in the treatment plant.

Figure 4. Historical Filamentous Algae Growth in the Rio Ruidoso.

Figure 5. Debris Flow Probability Map for the Little Bear Wildfire Burn Area. From Tillery and Matherne (2013).



Groundwater

Volcanic rocks are sometimes associated with high concentrations of arsenic and/or uranium in groundwater, but this does not appear to be the case in the Ruidoso area. Arsenic and uranium/gross alpha occur at low to less than detectable concentrations in all public supply wells that have been tested in the Ruidoso area.

High concentrations of sulfate and TDS, however, are widespread in wells completed in sedimentary bedrock. These high mineral levels are capable of impairing the aesthetic qualities of drinking water. Groundwater with the highest chemical quality occurs in volcanic bedrock terrain north of Eagle Creek (Figure 2, Fault, North Fork, Orchard and Sun Valley Wells).

While Ruidoso is not a heavily industrialized community, a number of underground petroleum storage tanks, onsite wastewater systems, and other potential manmade sources of contamination exist within some of the Source Water Protection Areas (Appendix A.2).

The original Hollywood well began pumping a mixture of groundwater and diesel fuel into the Ruidoso water distribution system on July 29, 1985, creating an emergency situation. Subsequent investigation determined that the source of contamination was a leaking underground diesel storage tank (Figure 6) located approximately 125 feet away from the Hollywood well. In 1987, a replacement well was drilled that is now also called the Hollywood well. NMED and the owner of the leaky storage tank signed a Settlement Agreement that provided for comprehensive investigation and cleanup of the spill. The site remains in a program of monitored natural attenuation.

Figure 6. Leaky Underground Storage Tank that Contaminated the Original Ruidoso Hollywood Well with Diesel Fuel in 1985.

VI. Source Water Monitoring and Protection Plan

Water Quality Issues

Ongoing water quality monitoring for compliance with the requirements of the federal Safe Drinking Water Act and the Maximum Contaminant Levels (MCLs) set by the U.S. Environmental Protection Agency provide a high level of protection from both natural and manmade sources of contamination. Concentrations of natural arsenic and uranium have been low in all Ruidoso supply wells, and any new wells will have to undergo rigorous testing for these and other parameters prior to pumping into distribution. With regard to the aesthetic problems that can be caused by high levels of naturally occurring sulfate and TDS, the Village of Ruidoso blends mineralized water from supply wells with high quality surface water, to the extent practical and as surface water supplies are available.

Testing for non-regulated geochemical parameters that can provide early warning of future contamination problems, or of increasing salinity caused by groundwater depletion, has been sporadic and incomplete. Some wells have never been tested for complete geochemistry and others only once. Available geochemistry data, therefore, are insufficient to determine whether long-term groundwater quality changes have occurred. The Village intends, as laboratory resources permit, to run a complete general chemistry test for each well at least once every three years. General chemistry parameters include calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, total dissolved solids and pH. The Village also intends to purchase a field instrument to measure specific conductance. Specific conductance will be measured at each wellhead on a quarterly basis for two years, and then the monitoring frequency will be evaluated by the Source Water Protection Team.

Sustainability Issues

Ruidoso is one of many communities in New Mexico where the sustainability of water quantity may be more important of a Source Water Protection issue than potential contamination. The ongoing severe drought has decreased the amount of water available from surface water sources, and has created wildfire hazards. The 2012 Little Bear Fire resulted in the temporary shutdown of the Alto Reservoir and Eagle Creek water sources.

Existing groundwater level data gathered by the Village and by the USGS often cover a decade or less, and sometimes contain measurement gaps spanning several years. Despite these limitations, hydrographs for the Gavilan Canyon well (Figure 5), Green (new) Well and North Fork Wells #1 and #3 (Appendix B) show net declines in static water levels that could be consistent with groundwater depletion, while the hydrograph for Alto Well #1 shows no decline in static water level. The Source Water Protection Team believes, however, that the data are insufficient at this

time to determine whether the observed water-level declines represent groundwater depletion or temporary declines related to ongoing drought.

The Village will continue to measure static and pumping water levels in its supply wells and will record measurements into hydrographs. The Source Water Protection Team will continue to review hydrographs prepared by the Village and by the USGS.

The Village Council recently adopted a tiered water rate structure to provide financial incentives for water conservation. The Village will monitor water usage over the next year for possible evidence of increased water conservation resulting from the tiered rate structure. Village of Ruidoso voters recently approved a bond issue that will provide increased revenue for the Village to perform a water audit, identify and repair leaks, and to upgrade aging drinking water infrastructure.

Public Outreach and Education

The Ruidoso community and the village government have a significant history of citizen activism and involvement. The Riverkeeper Program was developed by the Ruidoso River Association, Inc. in 1996 with Clean Water Act, Section 319, funding. This grassroots program obtained additional funding, including sponsorship from local businesses and individuals, hosted an annual river cleanup with food and music, and worked with the Village to post signs at locations where roads intersect streams (Figure 7) throughout the community. The Ruidoso River Association appears to have become inactive around the time of the catastrophic flooding that occurred in Ruidoso in 2008, but the Riverkeeper signs are still posted. Additionally, the Village of Ruidoso has posted signs throughout the community to alert residents when water restrictions are in effect (Figure 8).

The Village of Ruidoso has a water conservation webpage http://ruidoso-nm.gov/water-conservation.html, and the Public Works Department has made presentations to public schools in the past. The Source Water Protection Team will review the Village water conservation website for possible improvements including links to useful information. The Team also will identify informational material regarding rooftop collection systems and the safe reuse of treated onsite domestic wastewater.

The Village will endeavor to develop a more formal program of outreach to the schools to include routinely scheduled presentations that rotate among various classes throughout the school year, as well as inviting classes on field trips to look at wells, reservoirs and treatment plants.

Regional Source Water Protection

The suggestion that was made in the February 12, 2014 public workshop, that the Source Water Protection Plan be expanded to the county scale, is consistent with guidance that the U.S. EPA has issued to states. EPA specifically recommends that Source Water Protection Plans be

developed at the scale of a watershed or groundwater basin to include multiple water systems and other stakeholders. Indeed, many other water systems in the region face the same challenges that the Village of Ruidoso faces with regard to risks of natural and manmade contamination, drought and wildfire. The Source Water Protection Team will work with other public water systems in the region, and with the Lincoln County government, to explore interest in developing a regional or county-scale Source Water Protection Plan.

Figure 7. Riverkeeper Sign in Ruidoso.

Figure 8. Village of Ruidoso Water Restrictions Sign.

VII. Conclusions and Action Items

The Village of Ruidoso has developed a combination of ground and surface water sources. Surface water contains low mineral content, but is often of insufficient quantity to supply the entire system, especially in times of drought. Groundwater quality varies widely, with the highest chemical quality occurring in volcanic rock aquifers north of Eagle Creek. Permian to Cretaceous sedimentary aquifers contain substantially higher concentrations of naturally occurring minerals, often exceeding recommended secondary MCLs for sulfate and total dissolved solids (TDS).

The Village water supply system faces a number of challenges from drought, potential groundwater depletion, natural and manmade contamination, wildfire and flooding. The Village recently updated its Emergency Response Plan for the water system.

Action Items

1. In order to better identify possible future changes in groundwater geochemistry and, as funding is available, water wells will be tested for general chemistry once every three years and for specific conductance quarterly for two years. After the initial two years, the Source Water Protection Team will review the data and monitoring frequency for specific conductance.
2. In order to better track future changes in aquifer water levels, the Village will measure water levels in its supply wells, and will record the measurements into hydrographs. The Source Water Protection Team will review these hydrographs, and hydrographs from other monitored wells, on an annual basis.
3. Village of Ruidoso voters recently approved a bond issue that will provide increased revenue for the Village to perform a water audit, identify and repair leaks, and to upgrade aging drinking water infrastructure.
4. The Village will review water usage over the next year for possible evidence of increased water conservation resulting from the recently adopted tiered rate structure.
5. The Source Water Protection Team will review the Village's water conservation webpage for possible improvements and additional links.
6. The Village will endeavor to develop a more formal program of outreach to local schools.
7. The Source Water Protection Team will work with other public water systems in the region, and with the Lincoln County government, to explore interest in developing a regional or county-scale Source Water Protection Plan.

VIII. References

Donohoe, L.C. 2004. Selected Hydrologic Data for the Upper Rio Hondo Basin, Lincoln County, New Mexico, 1945-2003. U.S. Geological Survey Scientific Investigations Report 2004-5275. http://pubs.usgs.gov/sir/2004/5275/

Hall, F.R. 1964. Chemistry of Water of a Section of the Eastern Flank of the Sacramento Mountains, Lincoln and Otero Counties, NM. https://nmgs.nmt.edu/publications/guidebooks/downloads/15/15_p0161_p0170.pdf

Kelley, V.C. and T. Thompson. 1964. Tectonics and General Geology of the Ruidoso-Carrizozo Region, Central New Mexico. N.M. Geological Society, 15th Field Conference Guidebook. https://nmgs.nmt.edu/publications/guidebooks/downloads/15/15_p0110_p0121.pdf

Miller, S., E. Melis, R. Perry and L. Sublett. Well Report for Village of Ruidoso Emergency Replacement of Well H-1497 (Green Well), Ruidoso, New Mexico. John Shomaker & Associates, Inc. consulting report.

Mourant, W.A.. 1963. Water Resources and Geology of the Rio Hondo Drainage Basin, Chaves, Lincoln, and Otero Counties, New Mexico: New Mexico State Engineer Technical Report 28.

New Mexico Environment Department (NMED). 2006. Rio Hondo Watershed TMDLs. http://www.nmenv.state.nm.us/swqb/RioHondo-LincolnCounty/Intro.pdf

New Mexico Environment Department (NMED) Source Water Protection Atlas. http://gis.nmenv.state.nm.us/SWPA/

Rawling G.C. 2008. Geology of the Ruidoso area, Lincoln and Otero counties, New Mexico. Open-file Report 507. http://geoinfo.nmt.edu/publications/openfile/downloads/OFR500-599/500-525/507/ruidoso_area_geology_w_topo_base.pdf (map) http://geoinfo.nmt.edu/publications/openfile/downloads/OFR500-599/500-525/507/ruidoso_area_xsect_24k.pdf (cross sections)

Tillery, A.C., and Matherne, A.M., 2013, Post Wildfire debris-flow hazard assessment of the area burned by the 2012 Little Bear Fire, south-central New Mexico: U.S. Geological Survey Open-File Report 2013–1108, 15 p., 3 pls., http://pubs.usgs.gov/of/2013/1108/.

U.S. Geological Survey (USGS)

- Groundwater Watch for Lincoln County, NM. http://groundwaterwatch.usgs.gov/countymaps/NM_027.html
- Water Watch for New Mexico http://waterwatch.usgs.gov/?m=real&r=nm&w=map

Wasiolek, Maryann. 1991. The Hydrogeology of the Permian Yeso Formation within the Upper Rio Hondo Basin and the Eastern Mescalero Apache Indian Reservation, Lincoln and Otero Counties, New Mexico, *in* New Mexico Geological Society Guidebook: 42nd Field Conference, Sierra Blanca, Sacramento and Capitan Ranges.

Wilson & Company, Inc. 2004. Village of Ruidoso, NM, 40-Year Water Plan.

VILLAGE OF RUIDOSO
SOURCE WATER PROTECTION PLAN

APPENDIX A.1
SURFACE WATER SOURCES AND PROTECTION AREAS

March 27, 2014

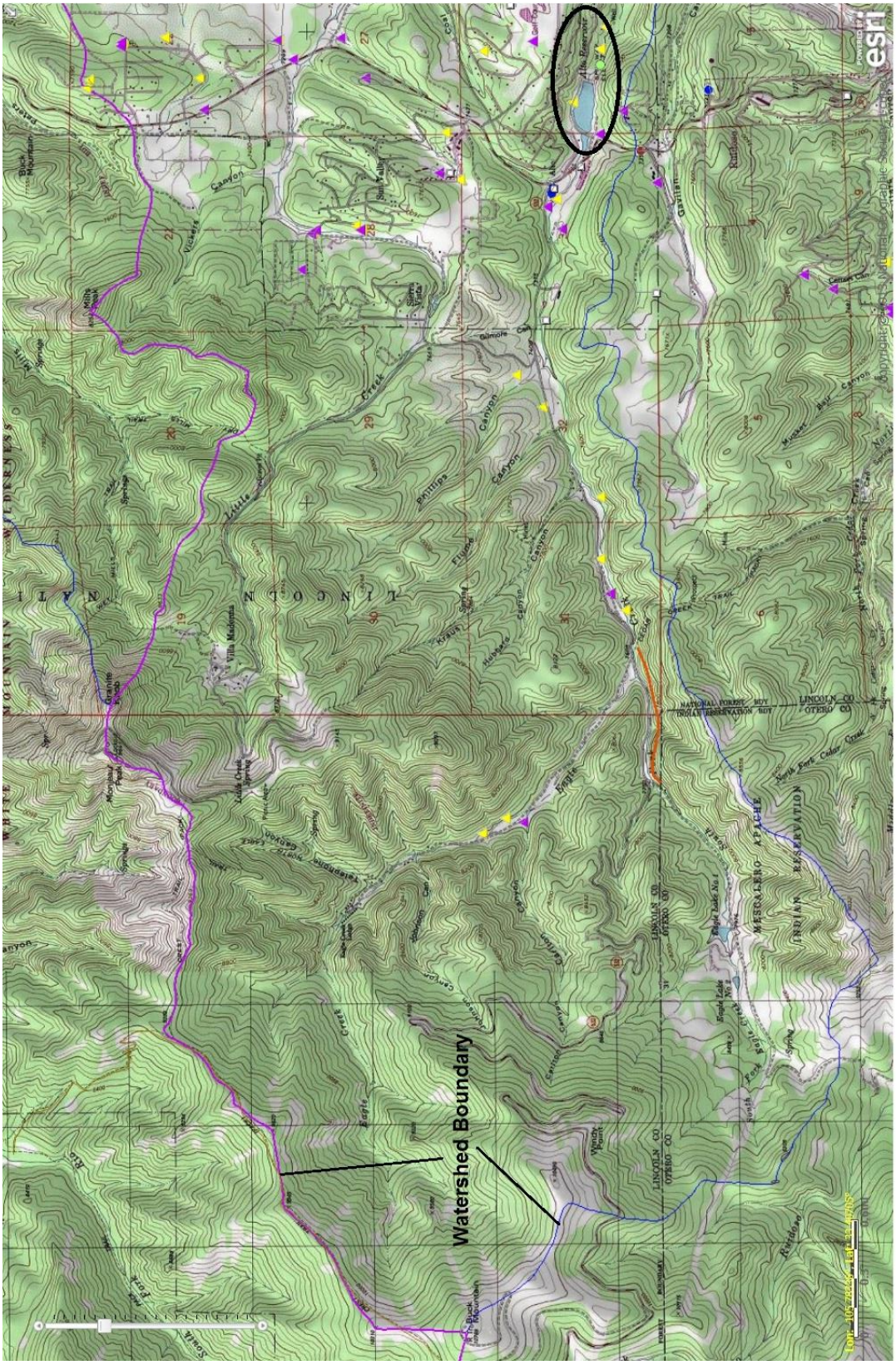
All Photographs were taken on February 12-13, 2014.

Source Water Protection Area base maps were created with the Source Water Protection Atlas http://gis.nmenv.state.nm.us/SWPA/.

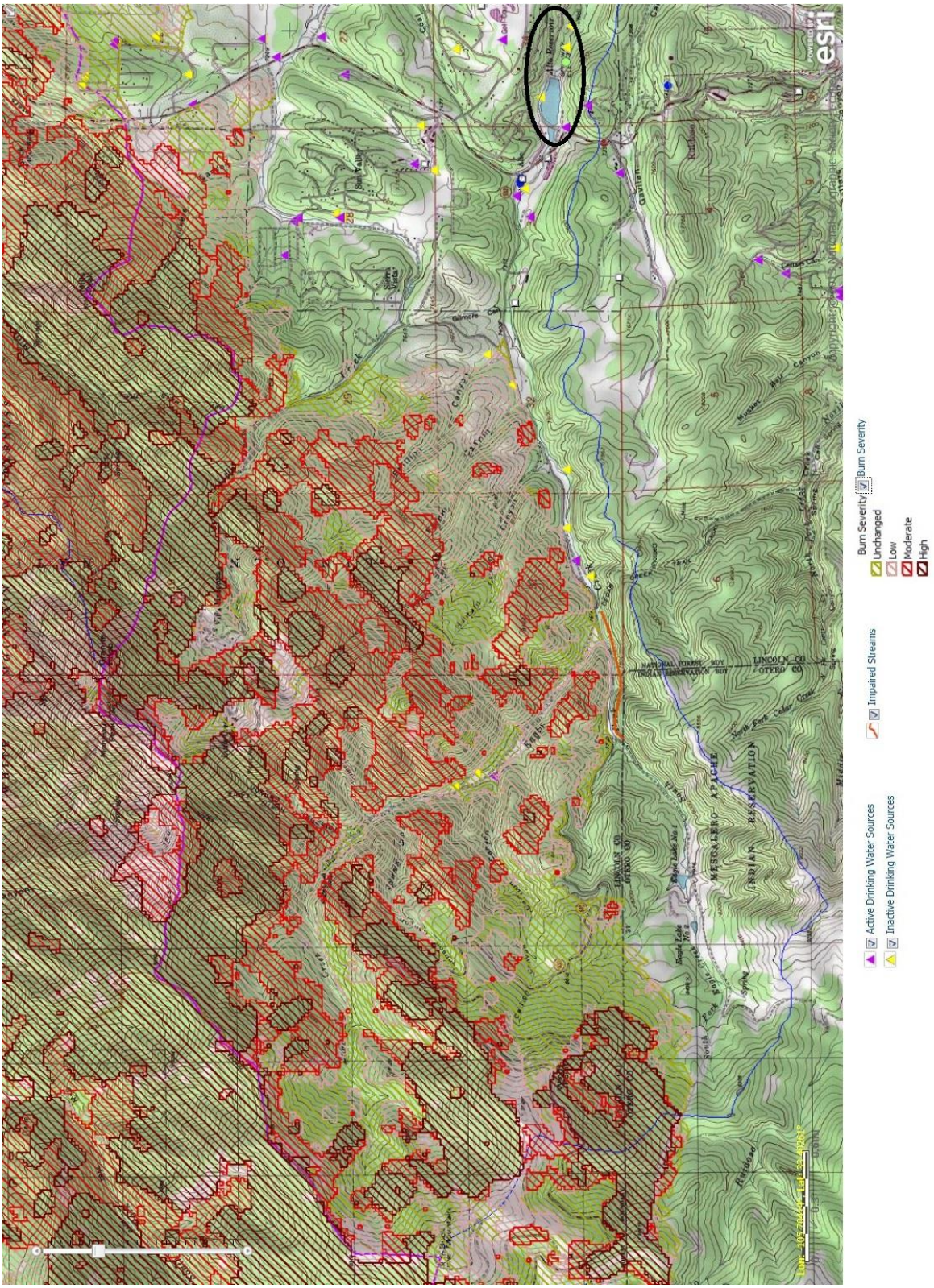
Alto Reservoir

Alto Reservoir is located on Eagle Creek just west of Highway 48 in Alto. The Eagle Creek watershed was heavily damaged by the Little Bear Wildfire. Runoff from the burn scar has caused the use of Alto Reservoir as a source of drinking water for the Village of Ruidoso to be temporarily suspended. The Village intends to resume use of Alto Reservoir as a source of drinking water later this year. A number of manmade potential sources of contamination are located in the watershed including underground storage tanks for petroleum products and homes and cabins that utilize onsite wastewater systems. A segment of Eagle Creek about 2.7 miles upstream from Alto Reservoir has been identified as impaired by low flow alteration.

Alto Reservoir Source Water Protection Area

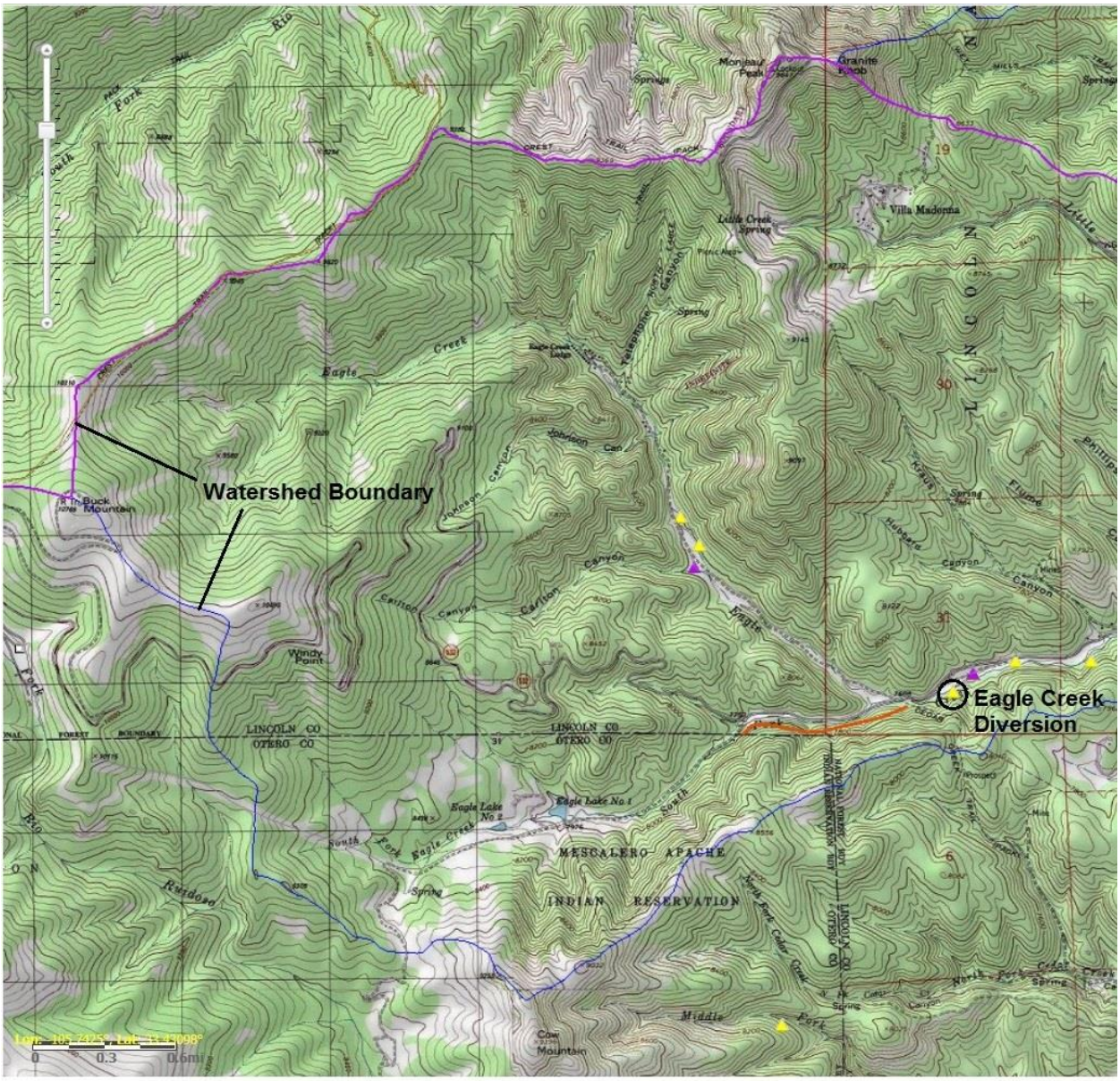


Alto Reservoir Source Water Protection Area (with Little Bear Wildfire burn scar)



Eagle Creek Diversion

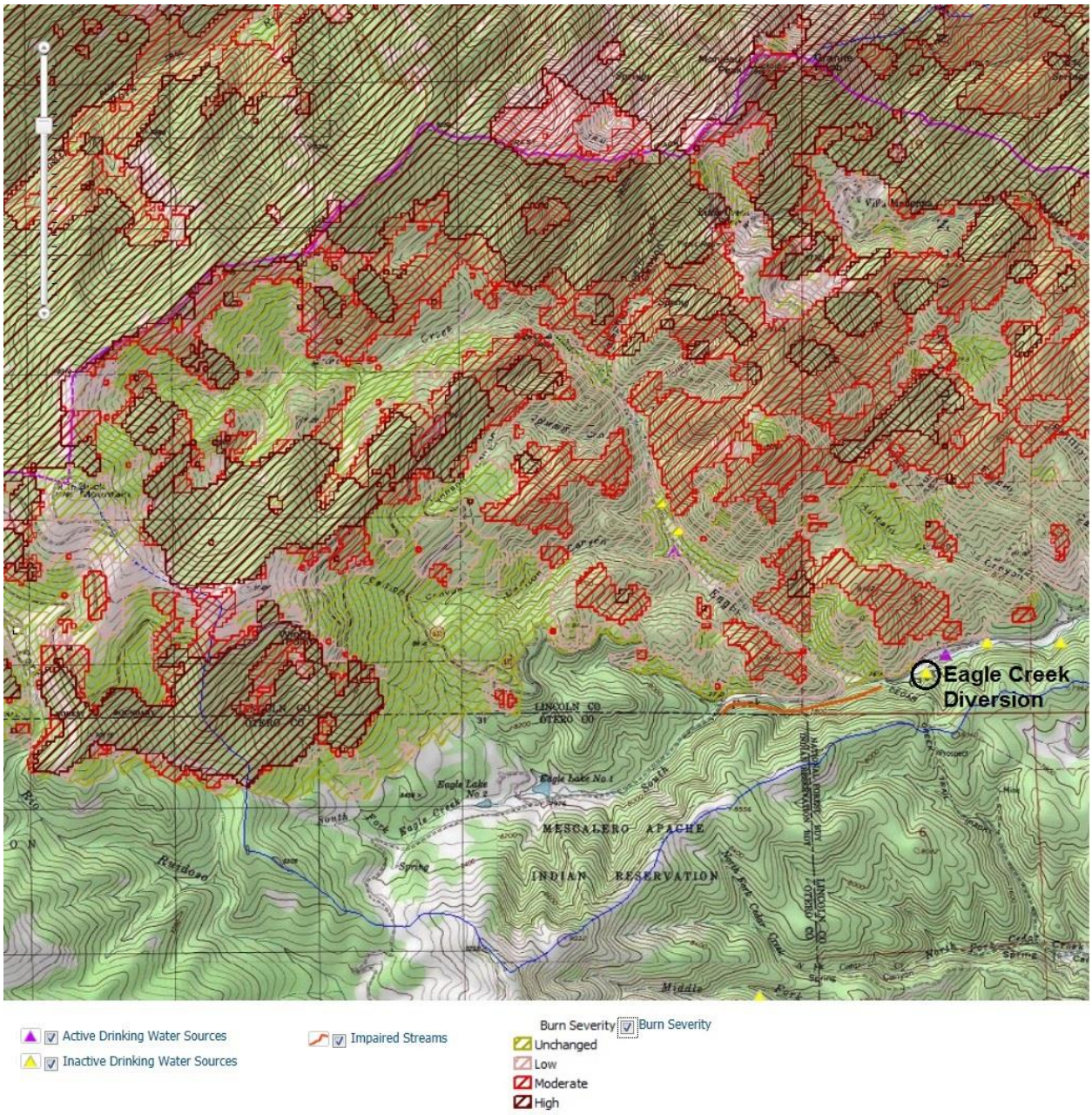
Eagle Creek Diversion Source Water Protection Area



Eagle Creek Diversion in the Devils Canyon Watershed

Active Drinking Water Sources
Inactive Drinking Water Sources
Impaired Streams **Eagle Creek, low flow alteration impairment**

Eagle Creek Diversion Source Water Protection Area (with Little Bear Wildfire burn scar)



Grindstone Reservoir

Grindstone Reservoir has a very small watershed located entirely within the Two Rivers Source Water Protection Area, and can receive water piped in from the Two Rivers and Upper Canyon Diversions. On the day this picture was taken, February 12, 2014, the water level in the reservoir was 51 feet below the elevation of the spillway.

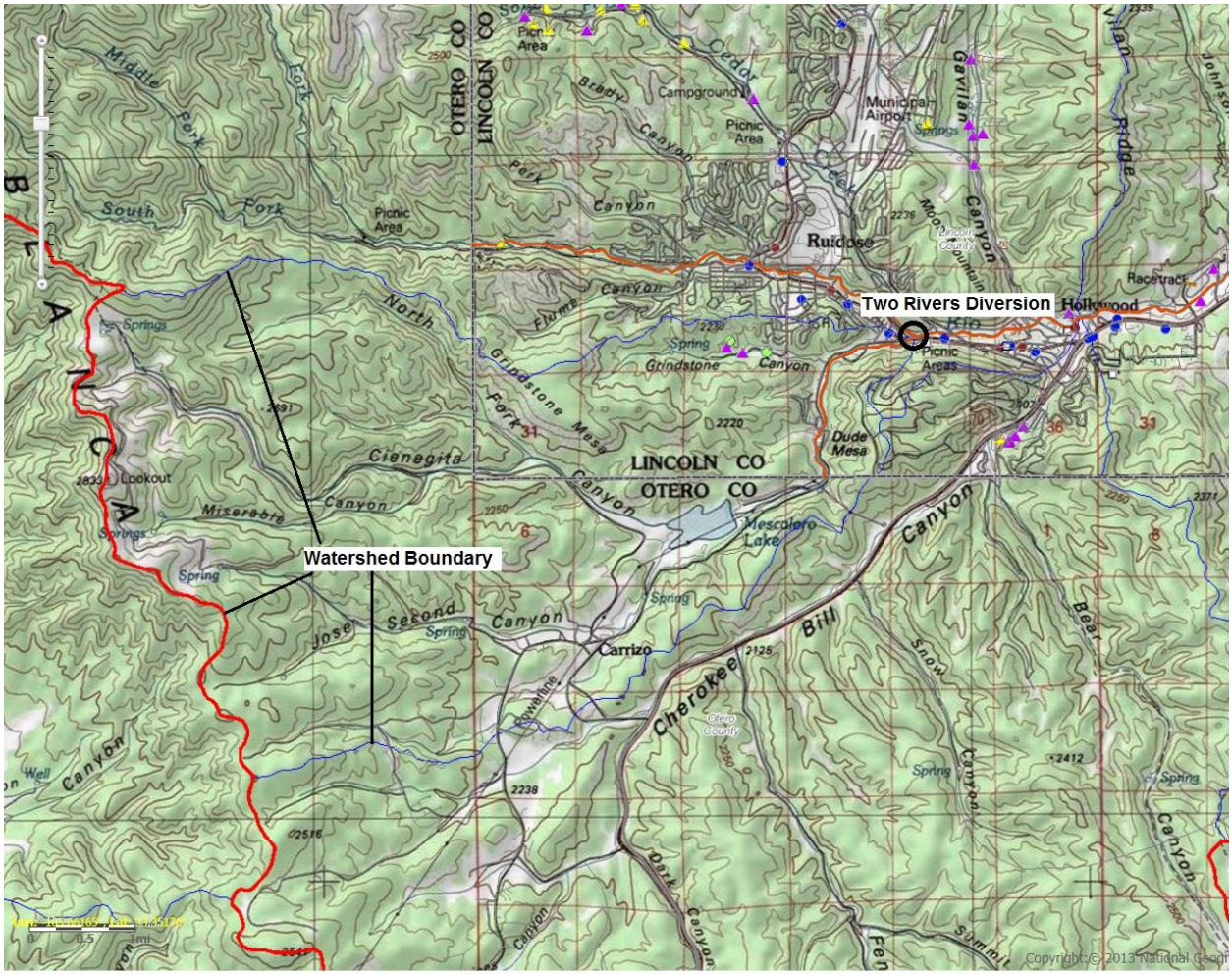
Grindstone Reservoir Source Water Protection Area

Two Rivers Diversion

The Two Rivers Diversion is located at the confluence of Carrizo Creek with the Rio Ruidoso and was given emergency authorization by the Office of the State Engineer. The Village of Ruidoso can divert water from this location up to Grindstone Reservoir when flow at the Hollywood gaging station reaches levels prescribed by the Office of the State Engineer. Both watercourses flow through developed areas with numerous potential sources of contamination. At the diversion location, Carrizo Creek is impaired with fecal coliform bacteria, and the Rio Ruidoso is impaired with temperature and turbidity. A number of homes and vacation cabins in the watersheds of these streams may utilize on site wastewater systems.

Two Rivers Diversion, looking upstream. Carrizo Creek is on the left, the Rio Ruidoso is on the right. Pump and hose are on the high ground upstream from the confluence.

Two Rivers Diversion Source Water Protection Area



Active Drinking Water Sources
Inactive Drinking Water Sources
Underground Storage Tank Facilities
Leaking Underground Storage Tank Sites

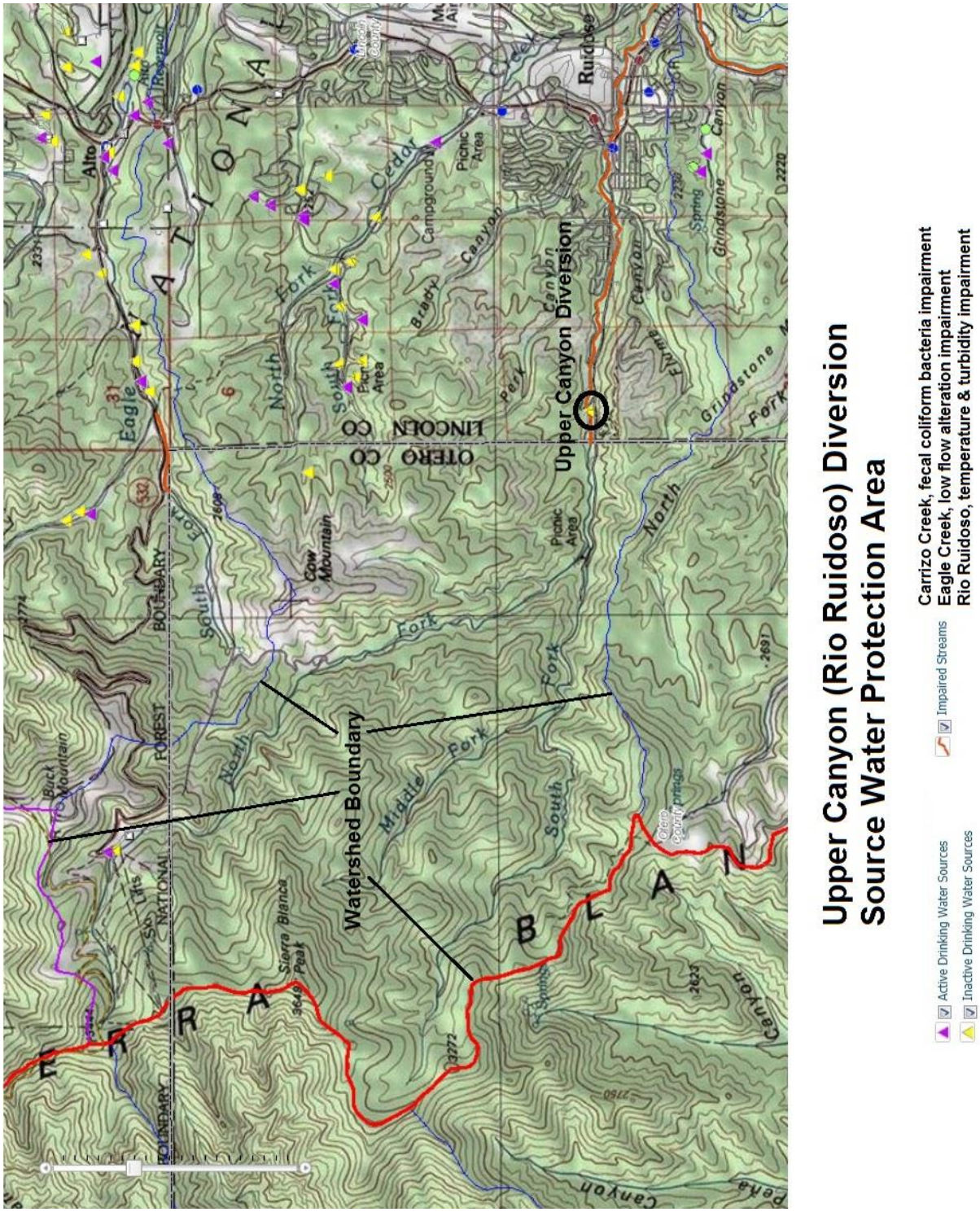
Impaired Streams

Carrizo Creek, fecal coliform bacteria impairment
Rio Ruidoso, temperature & turbidity impairment

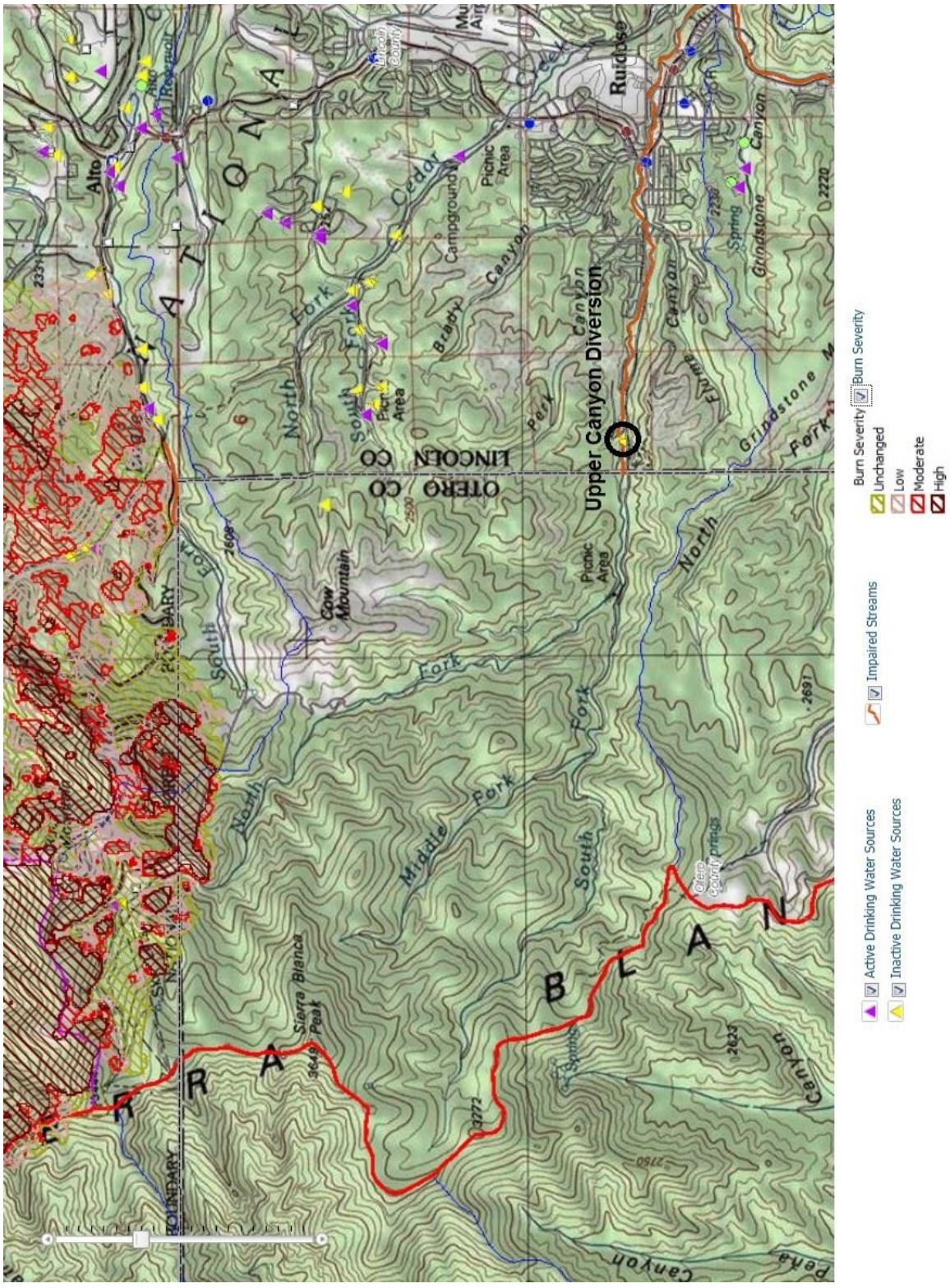
Upper Canyon (Rio Ruidoso) Diversion

The Upper Canyon Diversion is located on the Rio Ruidoso and water can be transferred to Grindstone Reservoir. The Rio Ruidoso at this location is impaired by temperature and turbidity. Additionally, a number of homes and vacation cabins in this area may still utilize on site wastewater systems even though public sewer service is available.

Upper Canyon (Rio Ruidoso) Diversion Source Water Protection Area



Upper Canyon (Rio Ruidoso) Diversion Source Water Protection Area (with Little Bear Wildfire burn scar)



VILLAGE OF RUIDOSO
SOURCE WATER PROTECTION PLAN

APPENDIX A.2
GROUNDWATER SOURCES AND PROTECTION AREAS

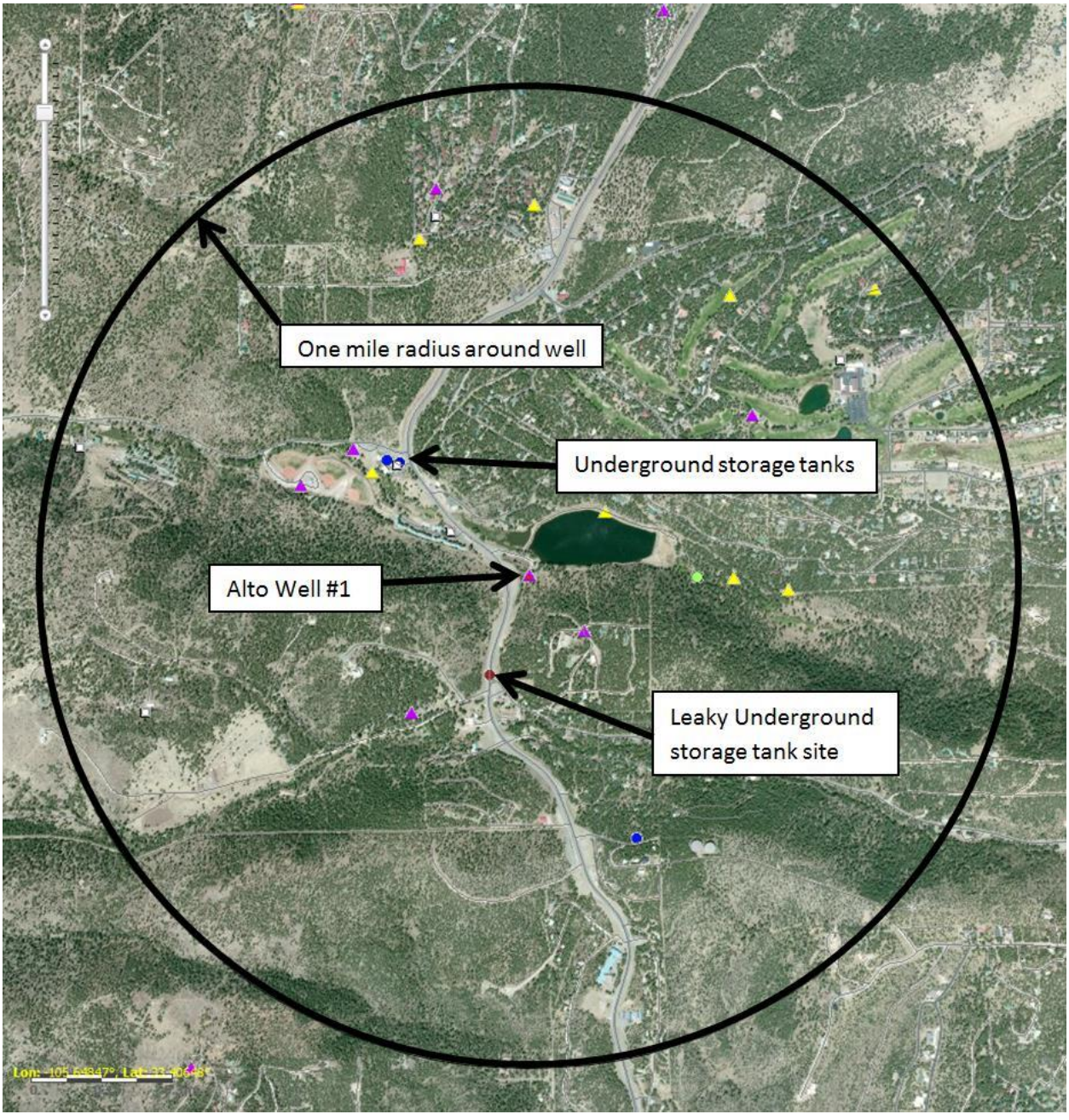
March 27, 2014

All Photographs were taken on February 12-13, 2014.

Source Water Protection Area base maps were created with the Source Water Protection Atlas http://gis.nmenv.state.nm.us/SWPA/.

Alto Well #1

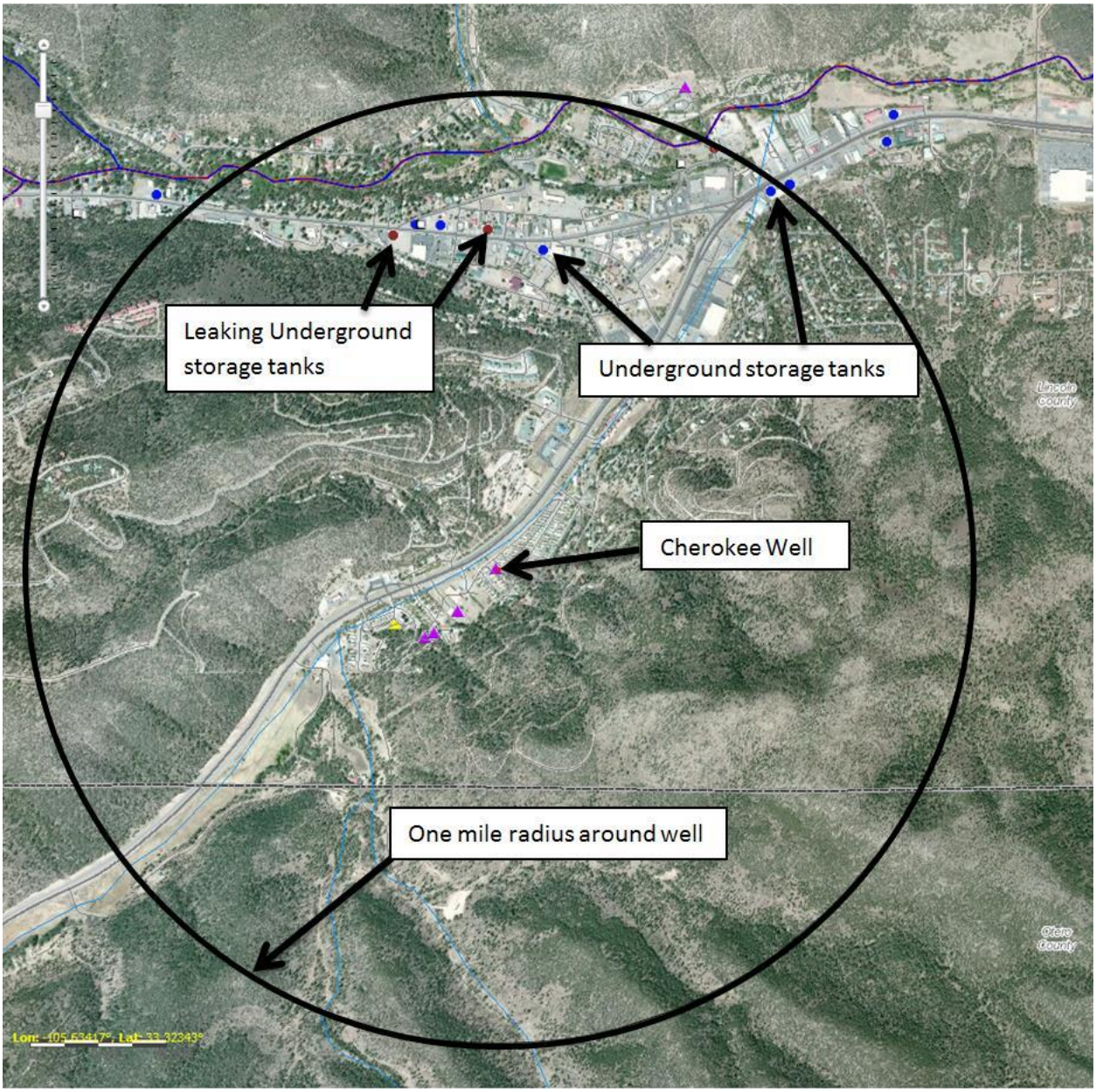
Alto Well #1 Source Water Protection Area



Cherokee Well

The Cherokee Well is located in a residential area along the lower reach of Cherokee Bill Canyon. Although the area has public sewer service, it is possible that onsite wastewater systems may exist in the region. The Village plans to install a fence around the well to restrict public access to the wellhead.

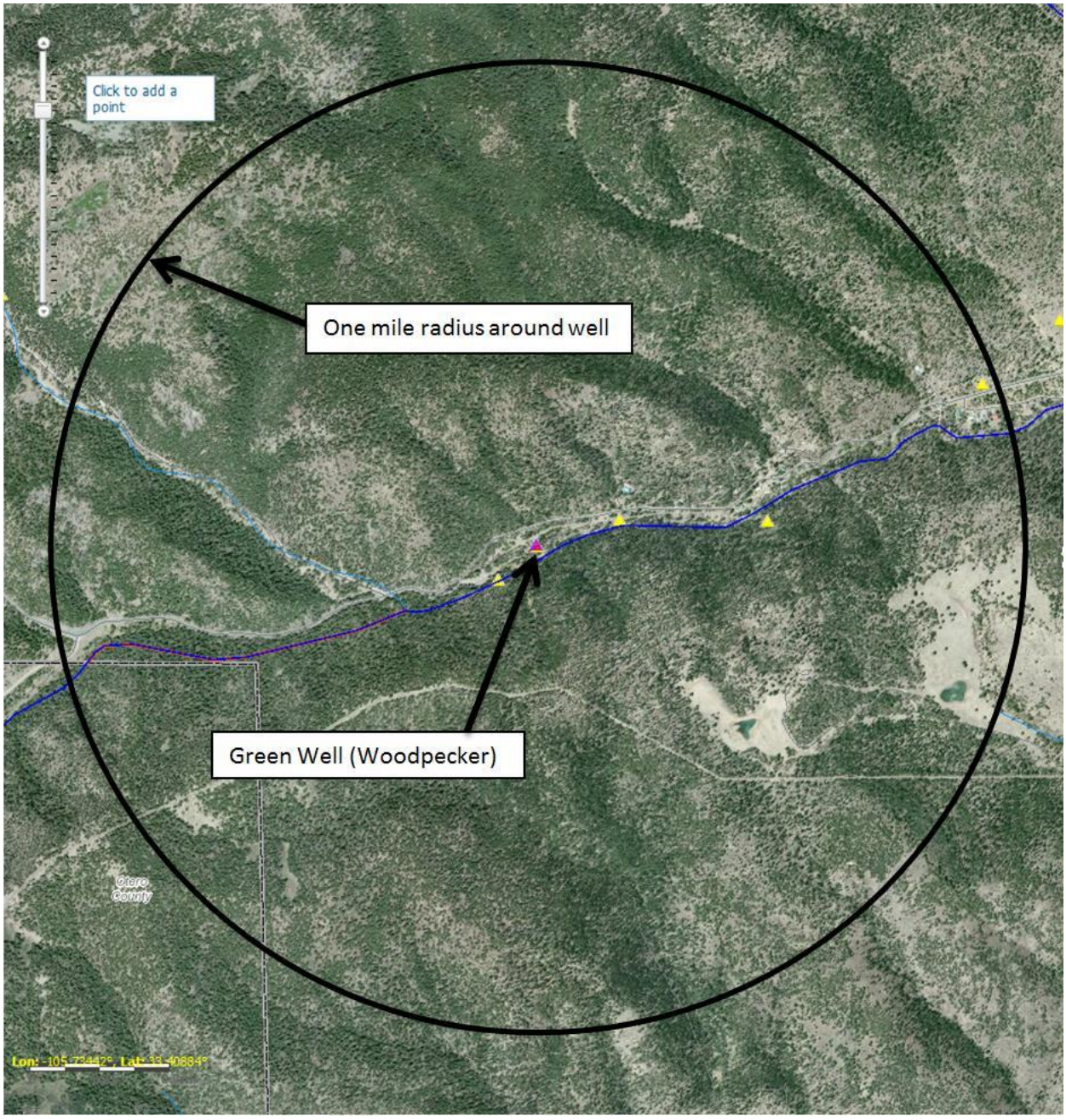
Cherokee Well Source Water Protection Area



Green Well

The Green Well (replacement) was drilled in 2007 to replace the original Green Well. It is located in Eagle Creek Canyon in a forested area with no known manmade potential sources of contamination. The road to Ski Apache and several unpaved roads, where petroleum products could be released in a motor vehicle accident, are in the area.

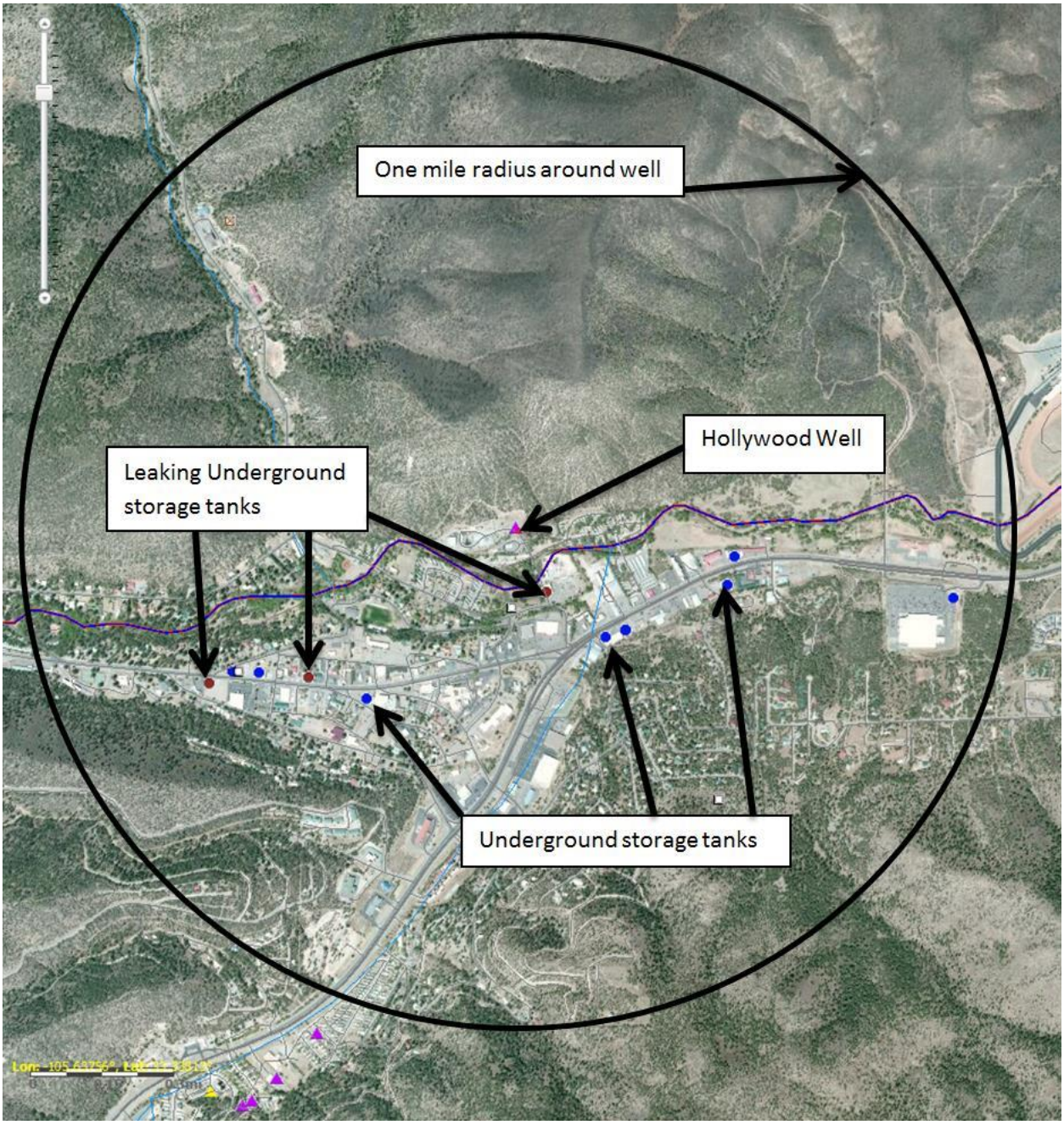
Green Well Source Water Protection Area



Hollywood Well

The existing Hollywood Well was drilled in 1987 to replace the original Hollywood Well that was contaminated in 1985 with diesel from a leaky underground storage tank. The existing well is located in the lower part of Ruidoso with a number of underground storage tanks located within a one mile radius. The well, however, sits on a hill slightly above the valley bottom.

Hollywood Well Source Water Protection Area

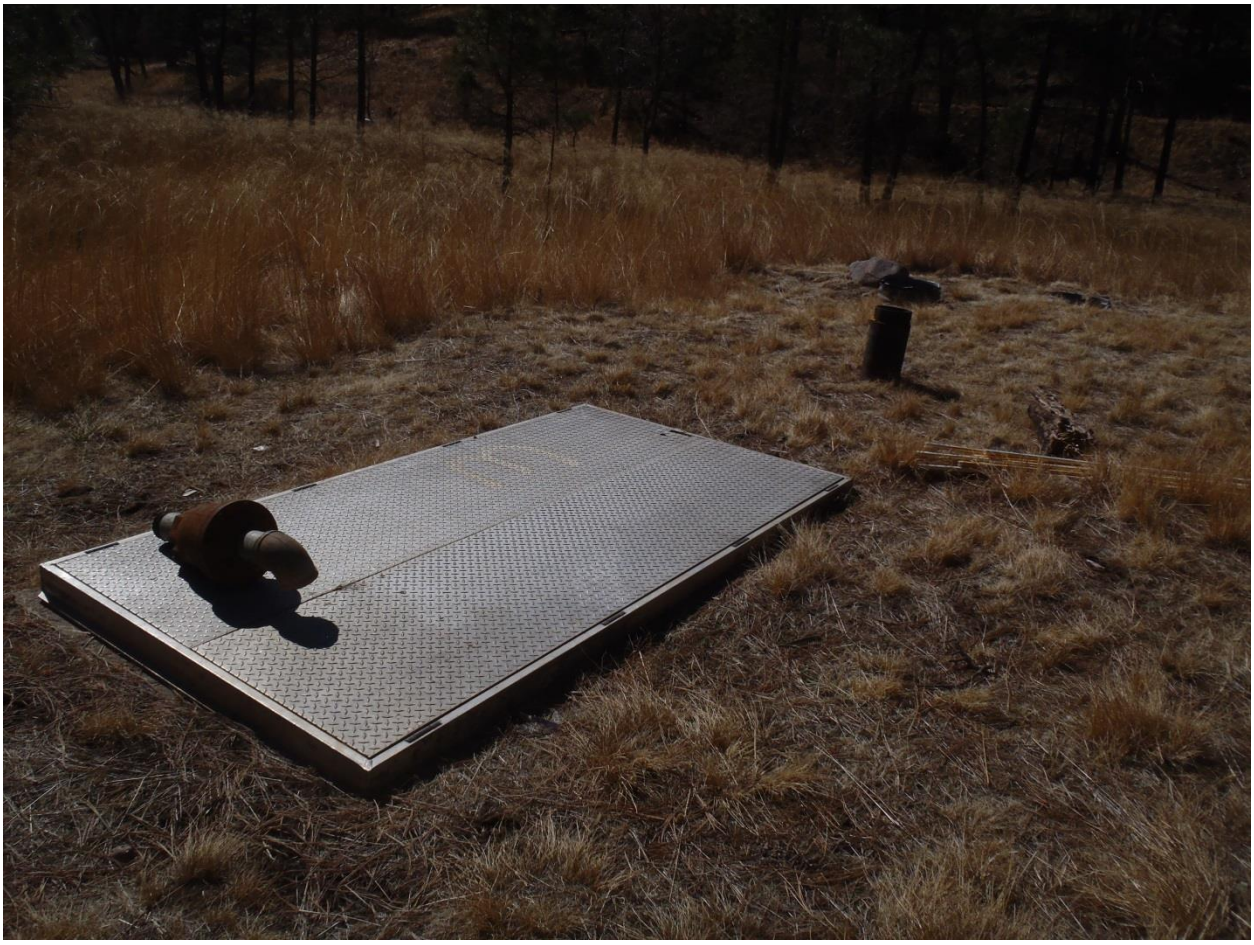


North Fork Well Field

The North Fork wellfield is located in the canyon of the north fork of Eagle Creek in a forested area with no known manmade potential sources of contamination. Well # 4 is the only well in this field that is utilized at the present time. The US Geological Survey has mapped this area as having some potential for debris flow from the Little Bear Burn wildfire burn area. Wells 1 and 3 are located near the canyon bottom, but are constructed in underground vaults. Well # 4 is located at a slightly higher position in the canyon. The road to Ski Apache and several unpaved roads, where petroleum products could be released in a motor vehicle accident, are in the area.

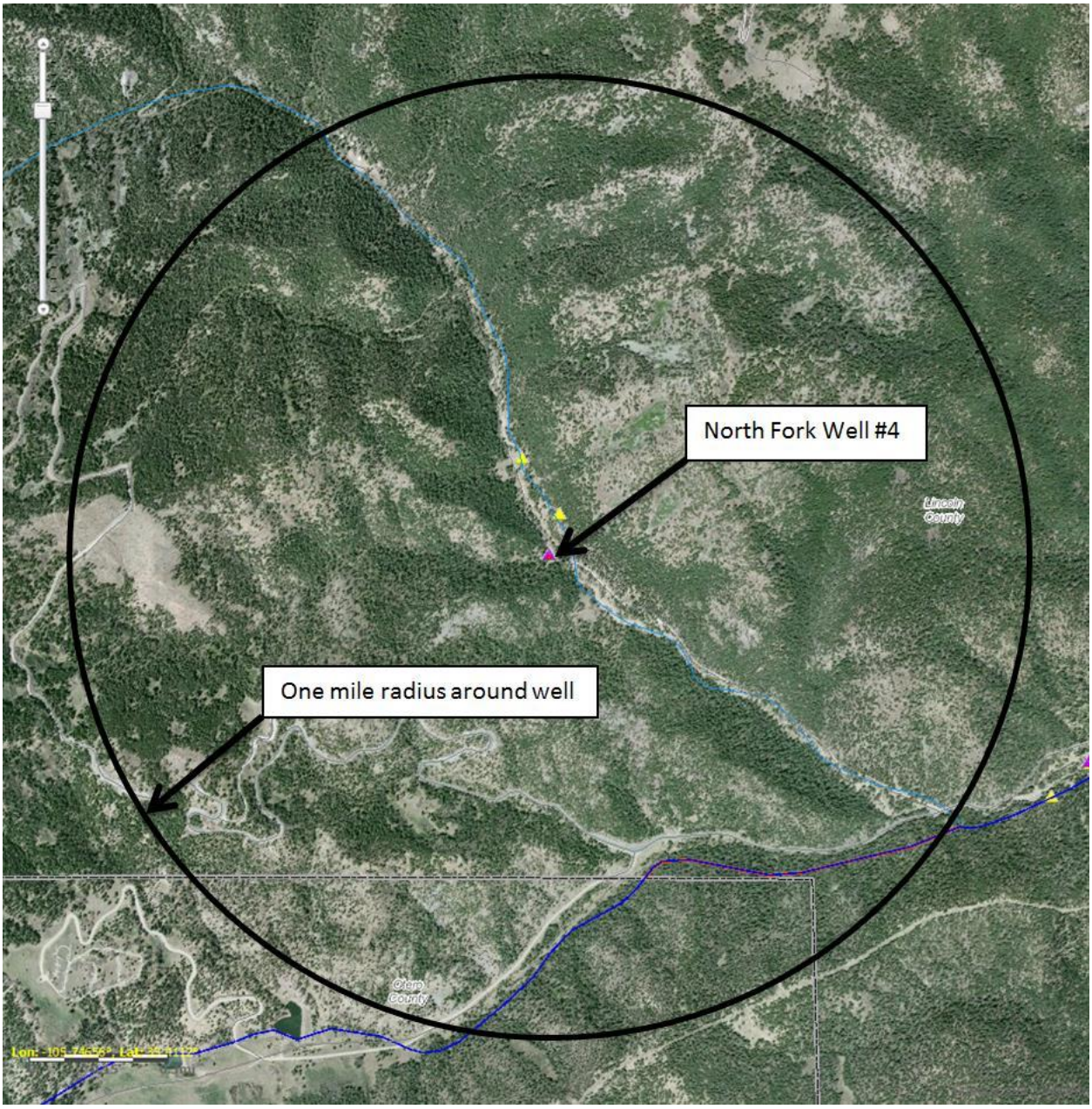
North Fork Well #1 (inactive)

North Fork Well #3 (inactive)



North Fork Well #4 (active)

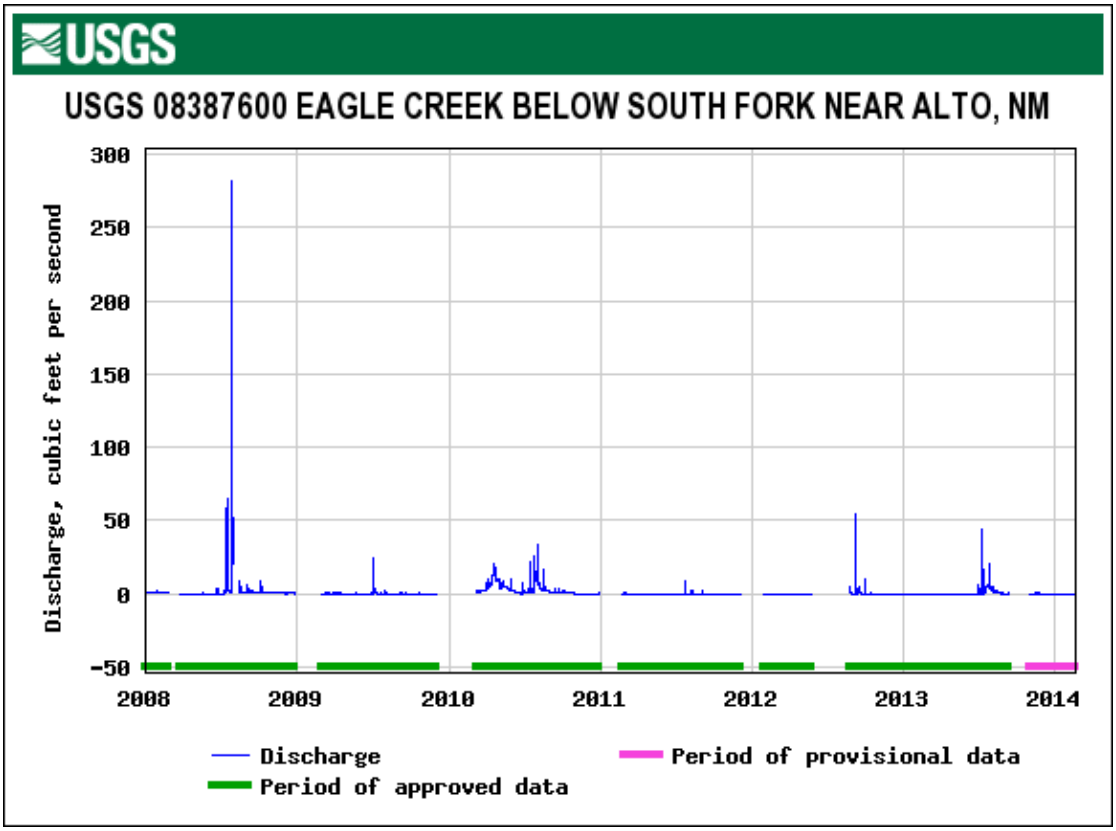
North Fork Well Field Source Water Protection Area

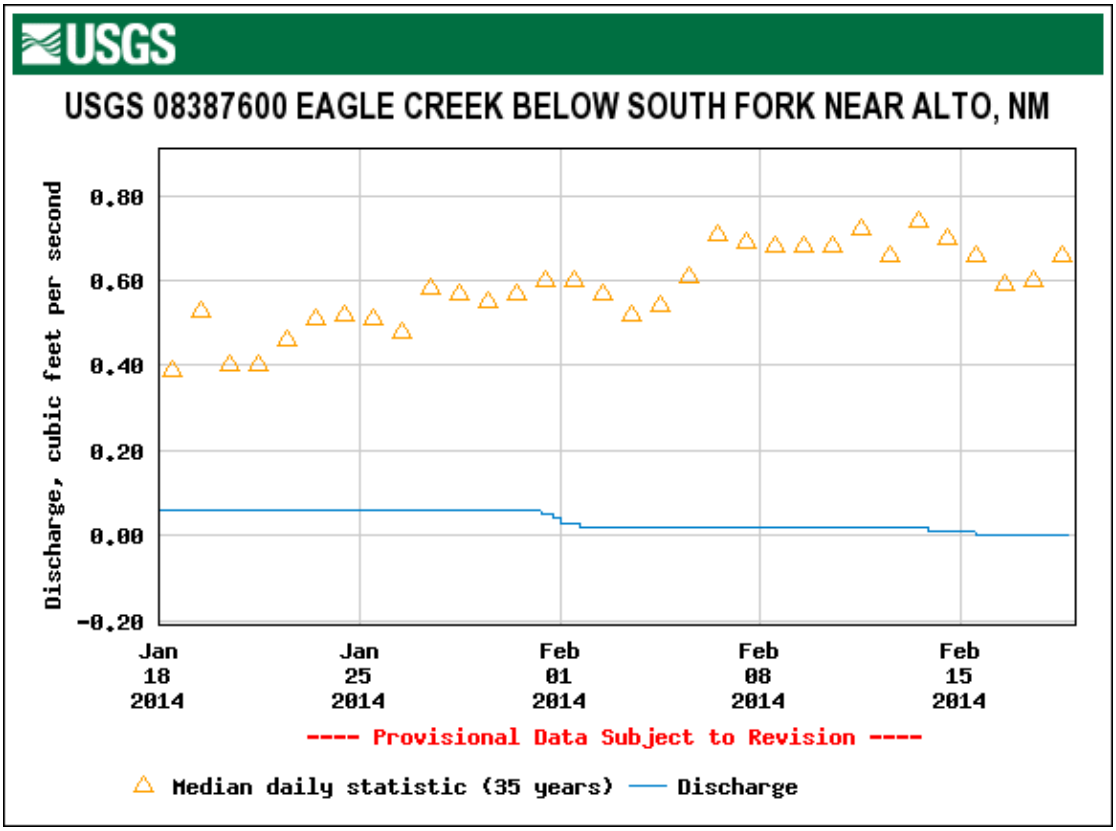


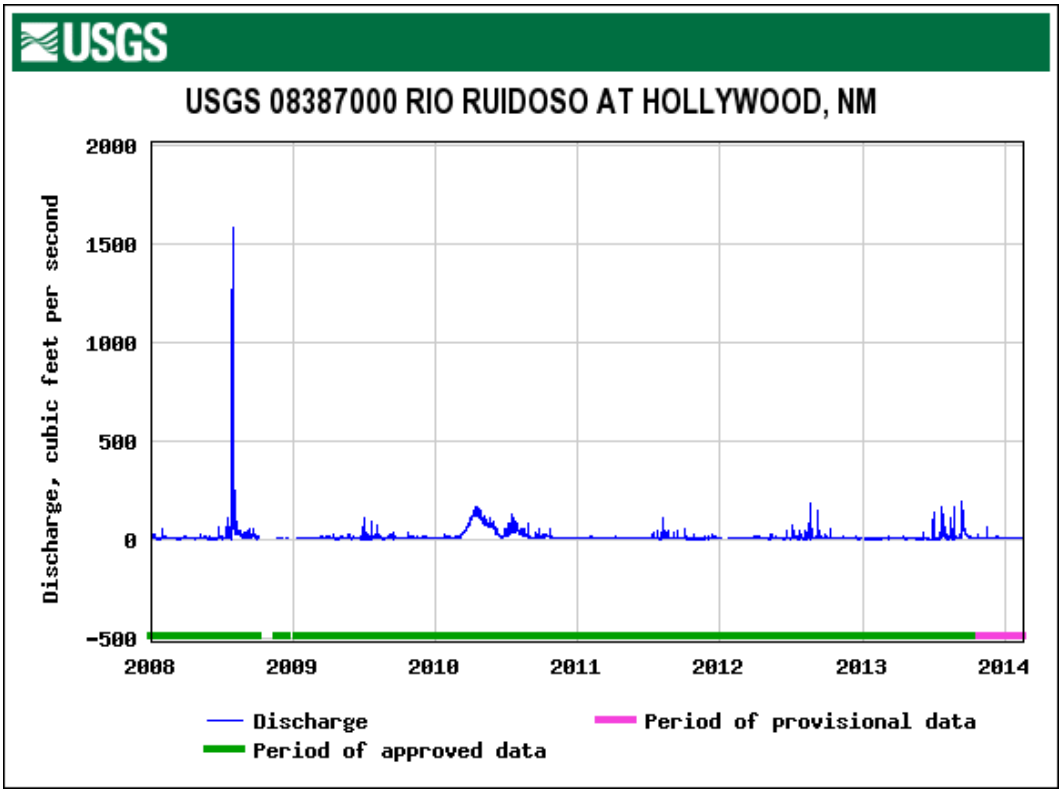
VILLAGE OF RUIDOSO
SOURCE WATER PROTECTION PLAN

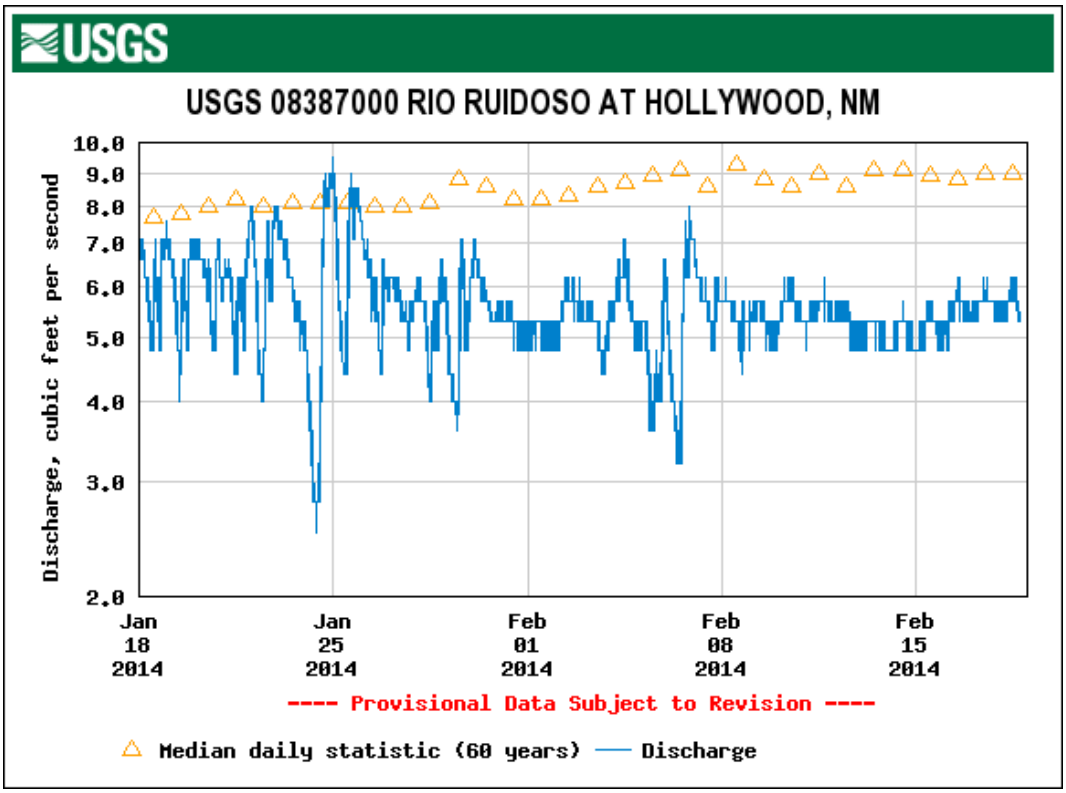
APPENDIX B
HYDROGRAPHS OF SURFACE AND GROUND WATER

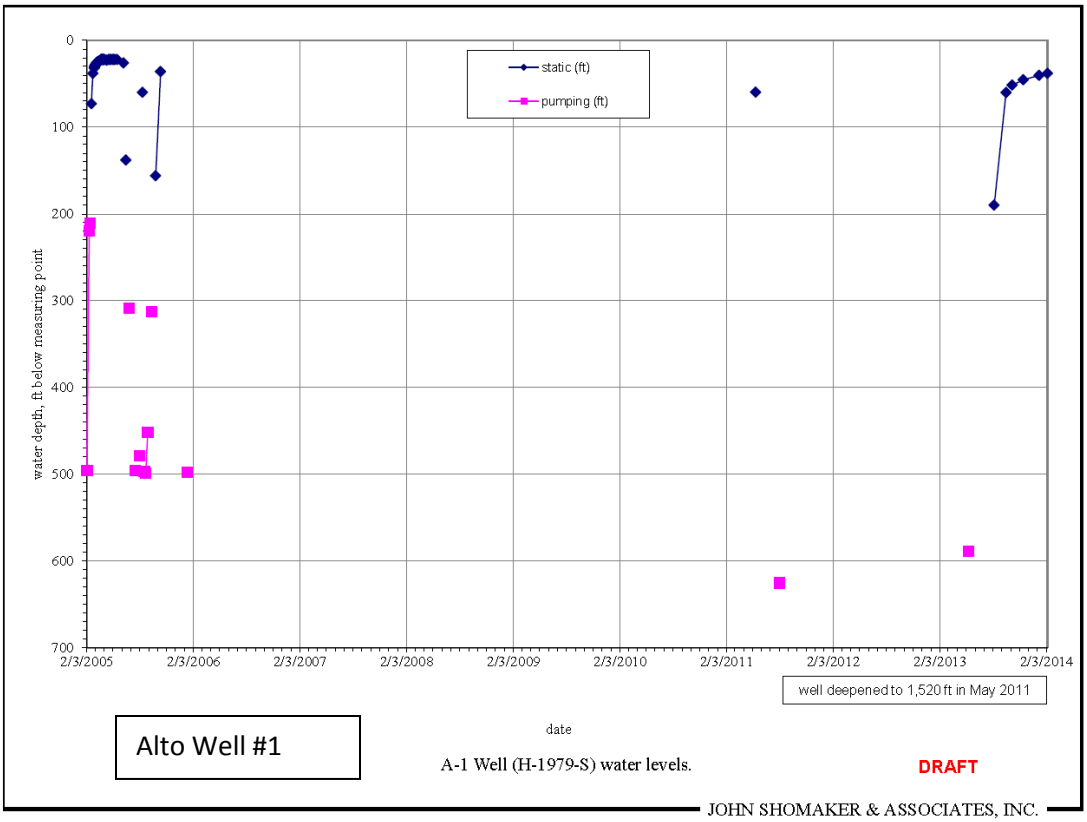
March 27, 2014

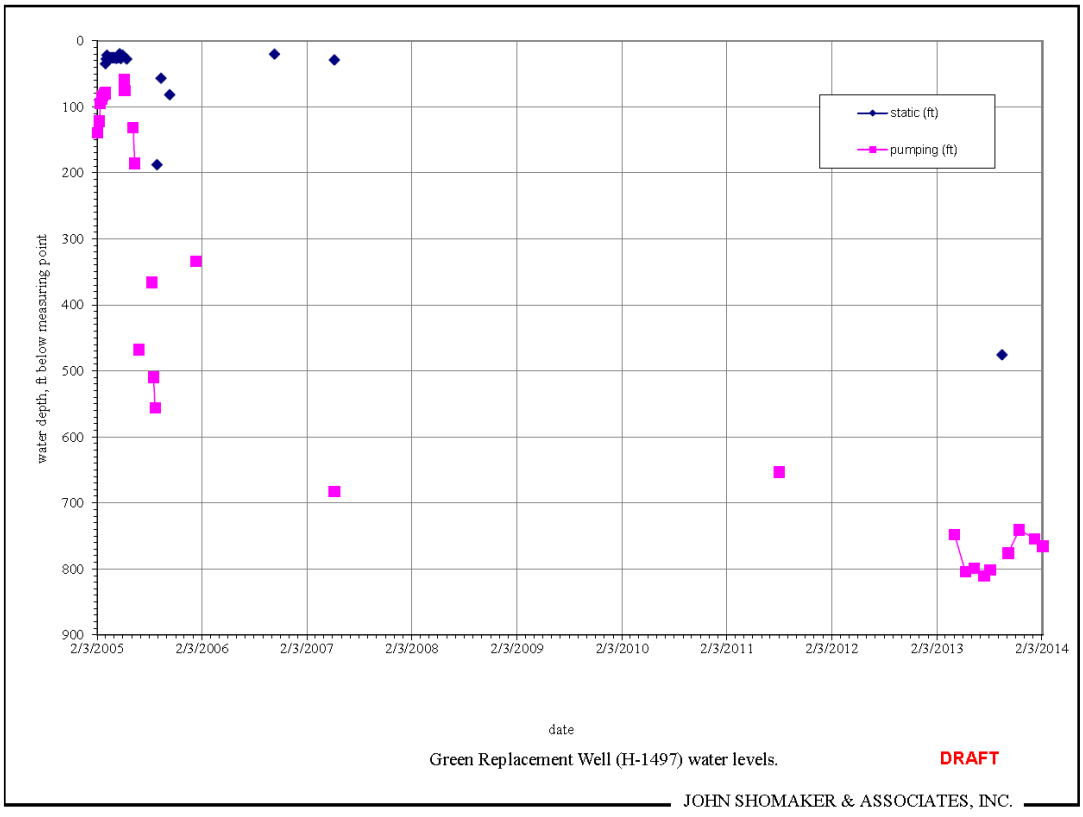

USGS
USGS 08387600 EAGLE CREEK BELOW SOUTH FORK NEAR ALTO, NM
Discharge, cubic feet per second
300
250
200
150
100
50
0
-50
2008
2009
2010
2011
2012
2013
2014
Discharge
Period of provisional data
Period of approved data

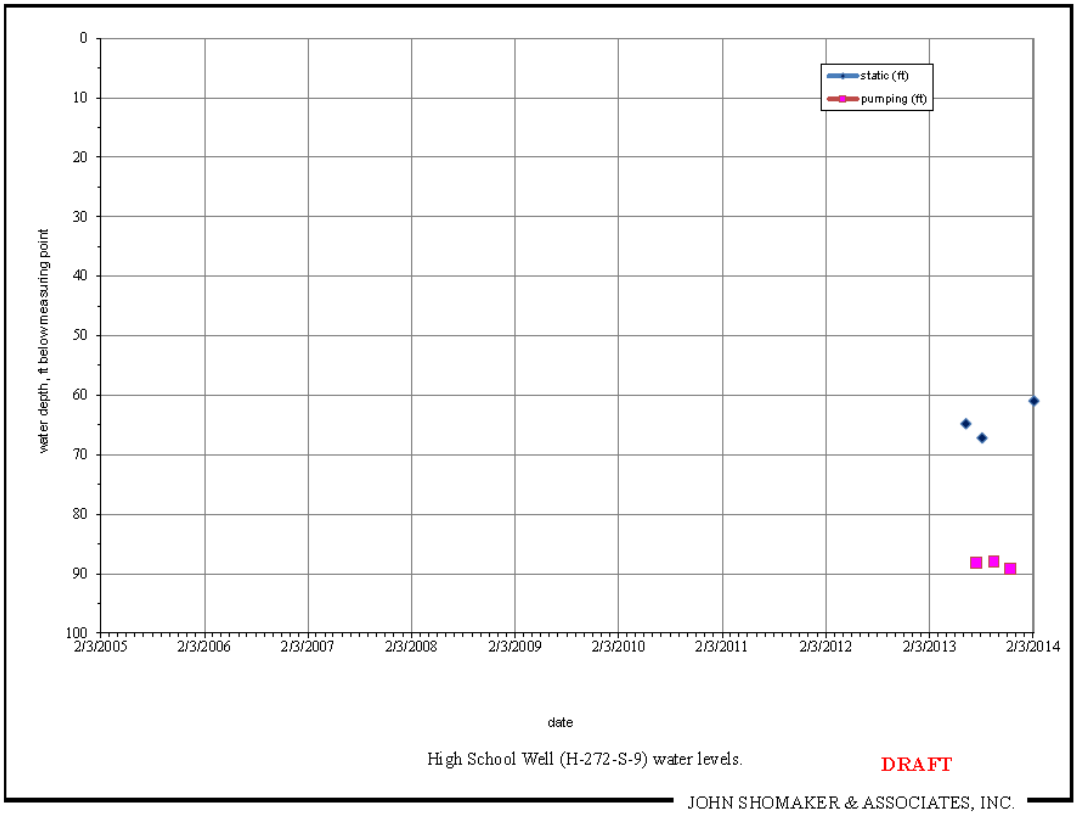

USGS
USGS 08387600 EAGLE CREEK BELOW SOUTH FORK NEAR ALTO, NM
Discharge, cubic feet per second
0.80
0.60
0.40
0.20
0.00
-0.20
Jan 18 2014
Jan 25 2014
Feb 01 2014
Feb 08 2014
Feb 15 2014
---- Provisional Data Subject to Revision ----
Median daily statistic (35 years)
Discharge


USGS
USGS 08387000 RIO RUIDOSO AT HOLLYWOOD, NM
Discharge, cubic feet per second
2000
1500
1000
500
0
-500
2008
2009
2010
2011
2012
2013
2014
Discharge
Period of provisional data
Period of approved data


USGS
USGS 08387000 RIO RUIDOSO AT HOLLYWOOD, NM
Discharge, cubic feet per second
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
Jan 18 2014
Jan 25 2014
Feb 01 2014
Feb 08 2014
Feb 15 2014
---- Provisional Data Subject to Revision ----
Median daily statistic (60 years)
Discharge


static (ft)
pumping (ft)
water depth, ft below measuring point
0
100
200
300
400
500
600
700
2/3/2005
2/3/2006
2/3/2007
2/3/2008
2/3/2009
2/3/2010
2/3/2011
2/3/2012
2/3/2013
2/3/2014
well deepened to 1,520 ft in May 2011
Alto Well #1
date
A-1 Well (H-1979-S) water levels.
DRAFT
JOHN SHOMAKER & ASSOCIATES, INC.

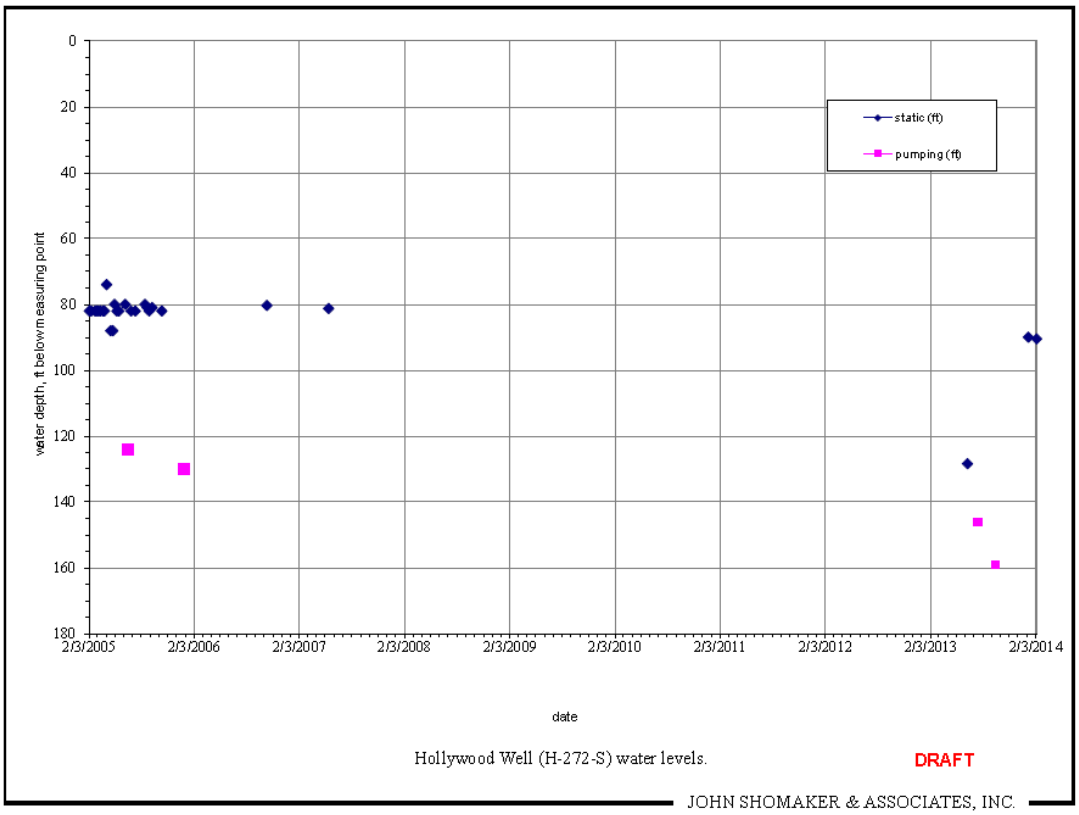

static (ft)
pumping (ft)
water depth, ft below measuring point
0
100
200
300
400
500
600
700
800
900
2/3/2005
2/3/2006
2/3/2007
2/3/2008
2/3/2009
2/3/2010
2/3/2011
2/3/2012
2/3/2013
2/3/2014
date
Green Replacement Well (H-1497) water levels.
DRAFT
JOHN SHOMAKER & ASSOCIATES, INC.



High School Well (H-272-S-9) water levels.

DRAFT

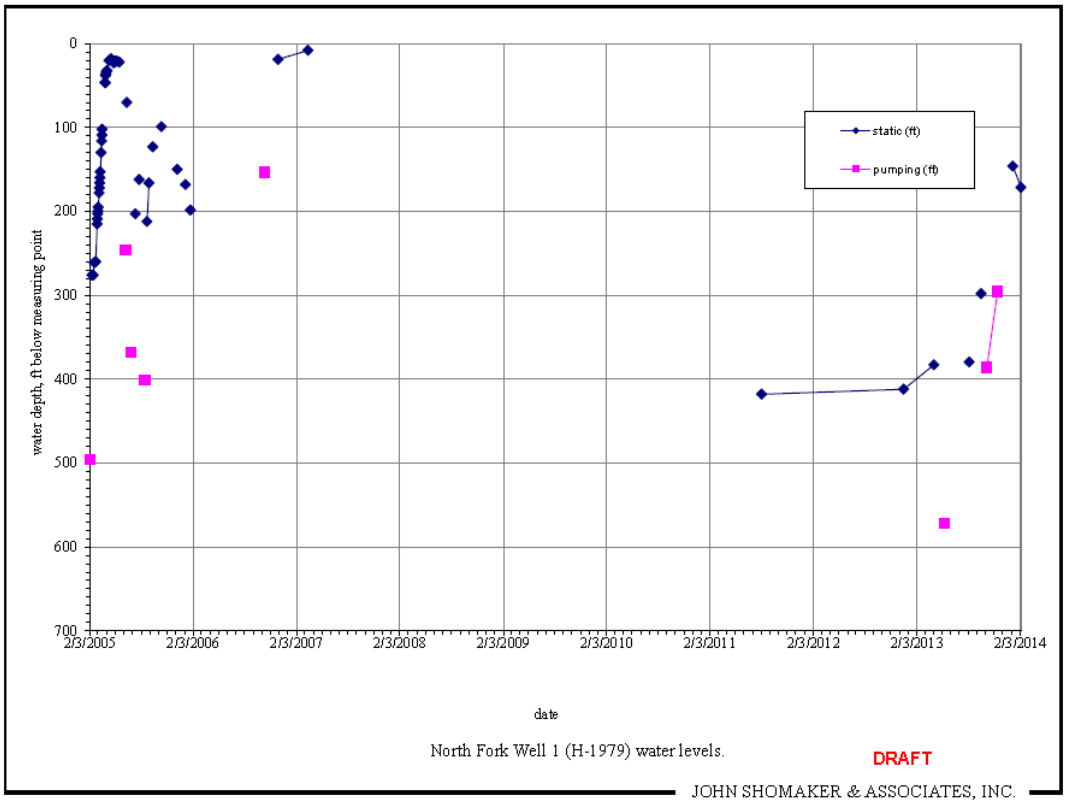
JOHN SHOMAKER & ASSOCIATES, INC.



Hollywood Well (H-272-S) water levels.

DRAFT

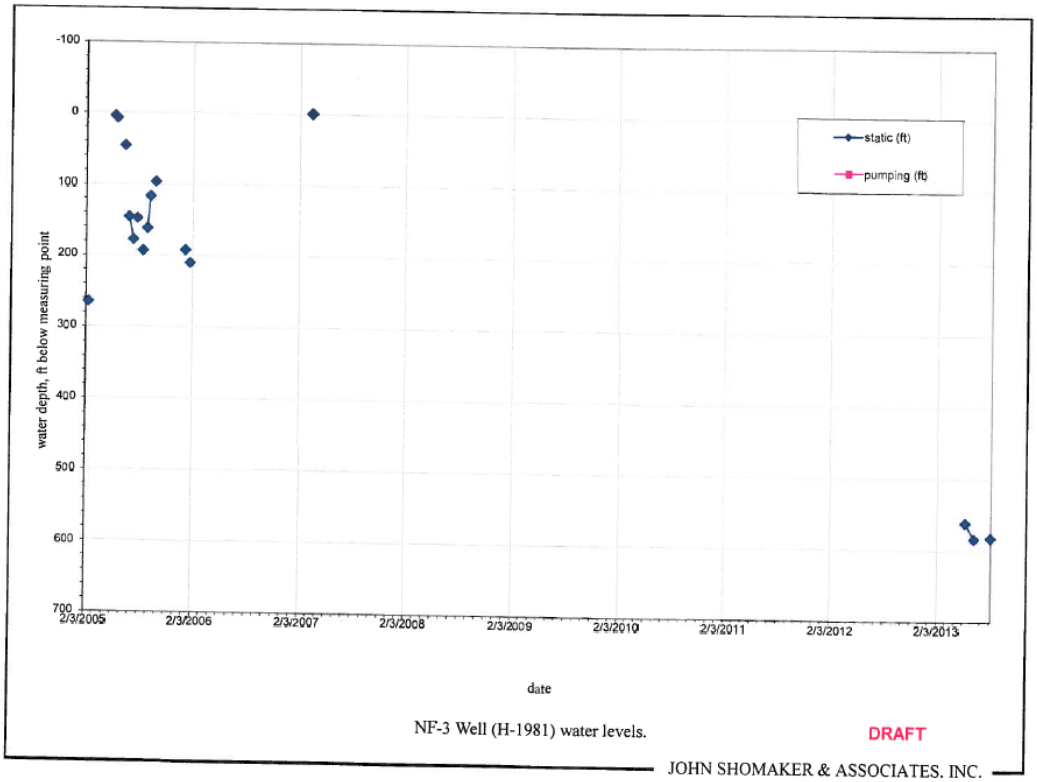
JOHN SHOMAKER & ASSOCIATES, INC.



North Fork Well 1 (H-1979) water levels.

DRAFT

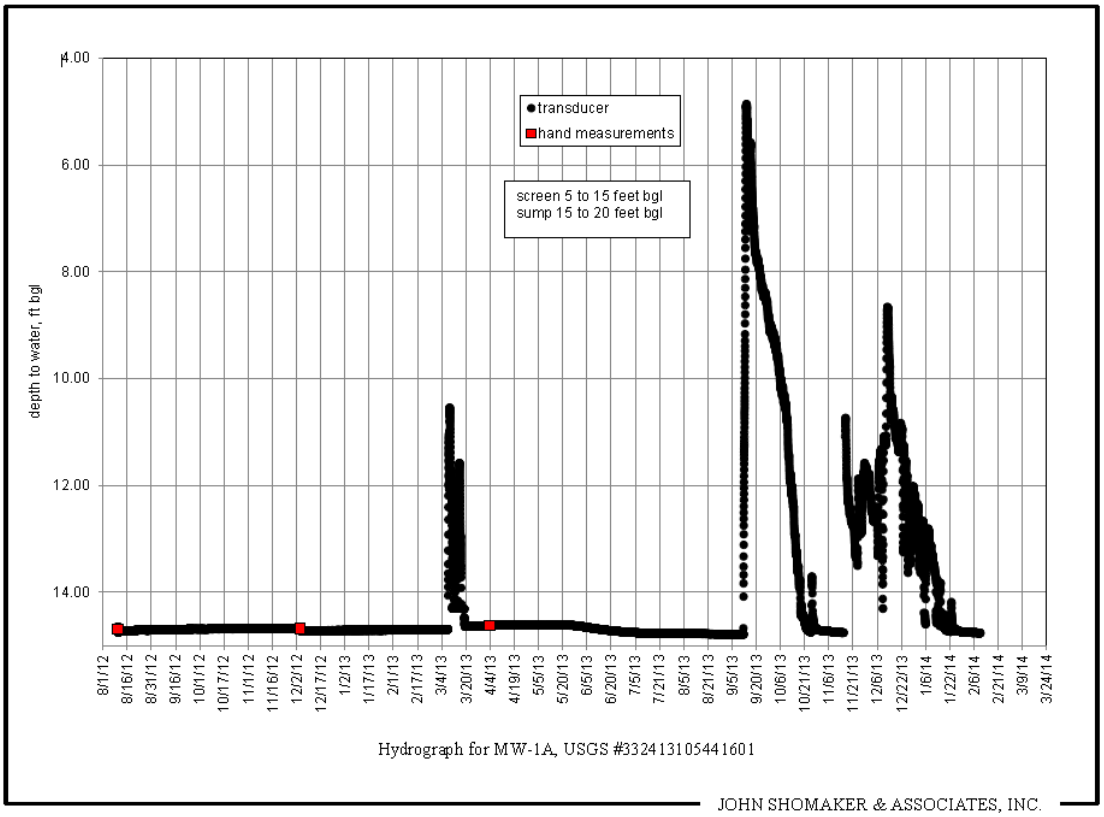
JOHN SHOMAKER & ASSOCIATES, INC.



NF-3 Well (H-1981) water levels.

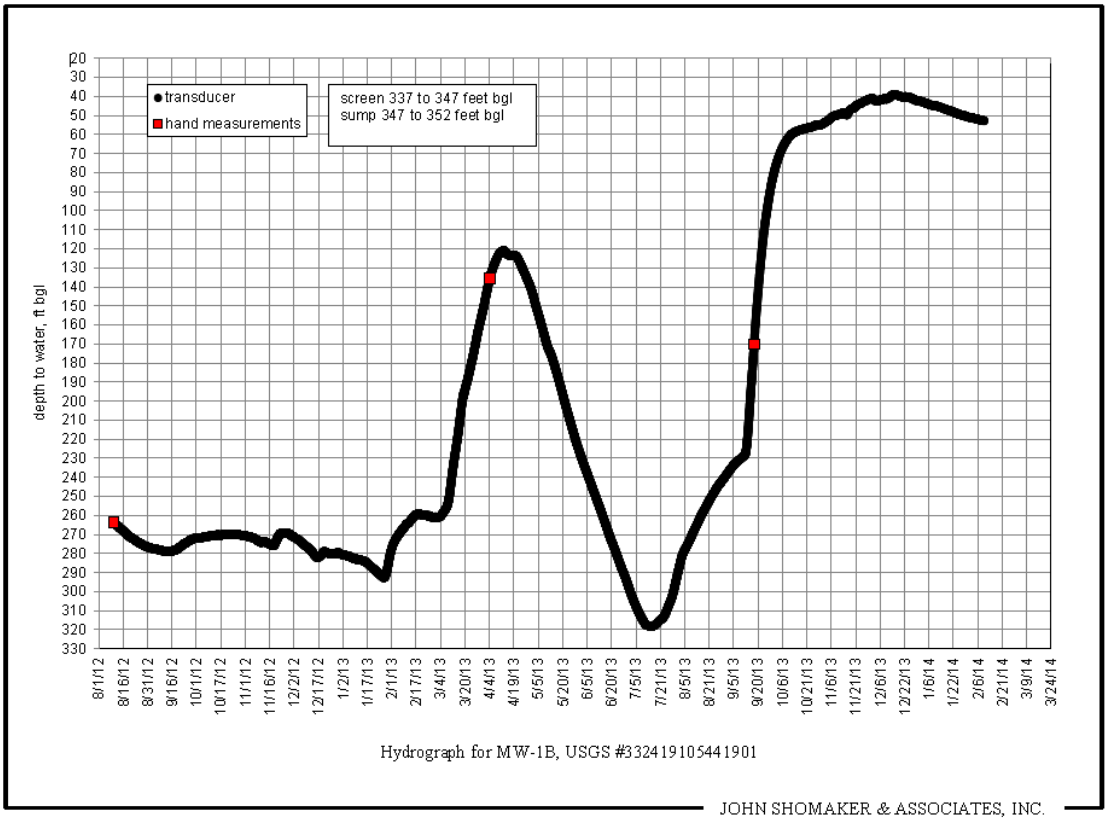
DRAFT

JOHN SHOMAKER & ASSOCIATES, INC.



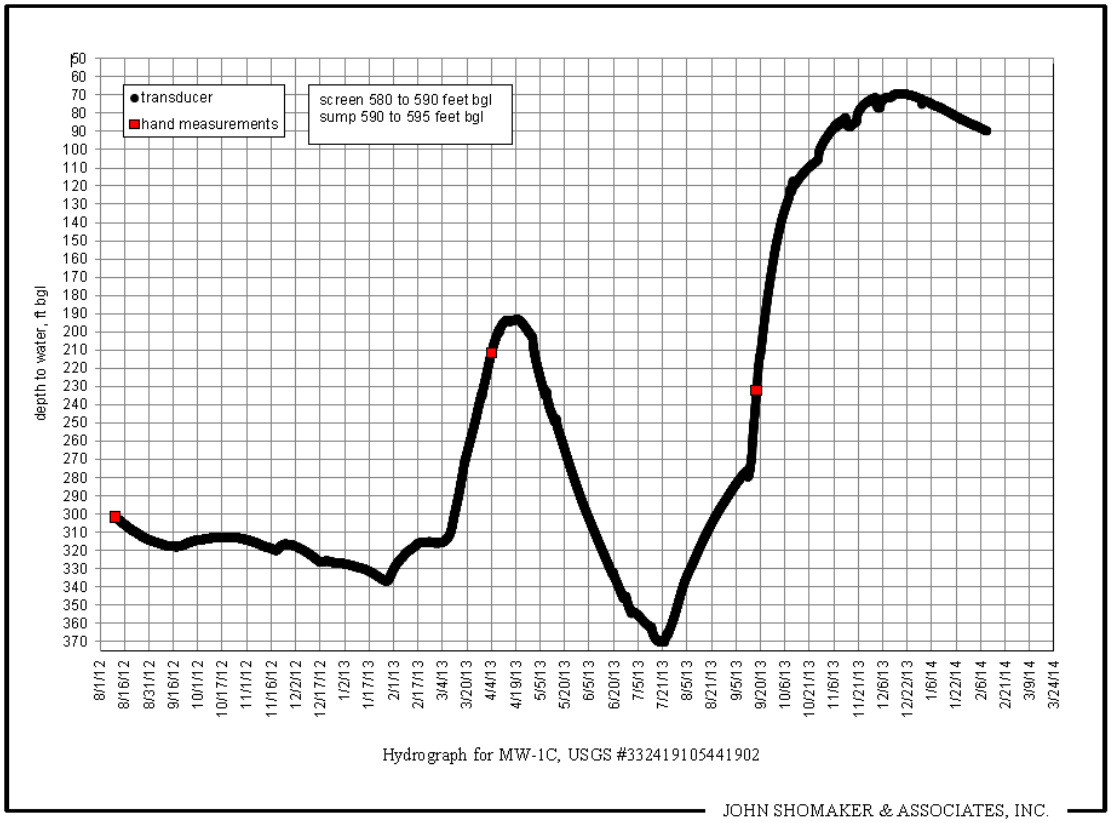
Hydrograph for MW-1A, USGS #332413105441601

JOHN SHOMAKER & ASSOCIATES, INC.



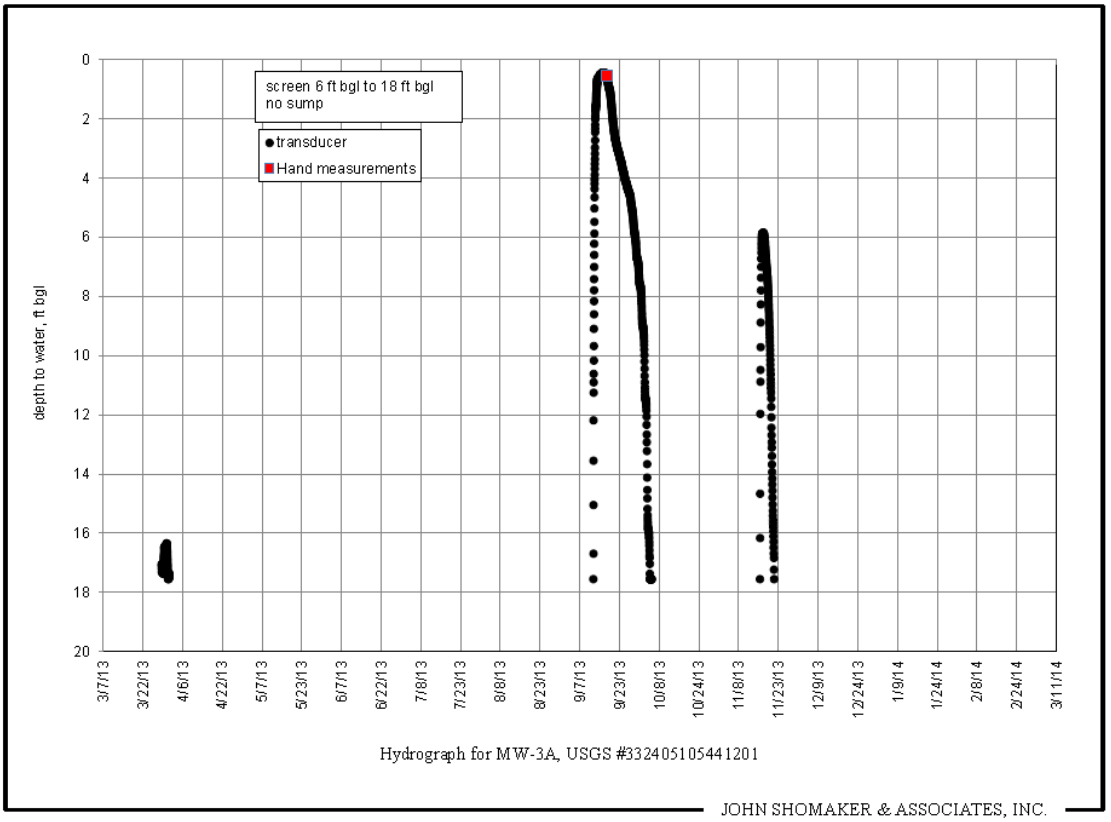
Hydrograph for MW-1B, USGS #332419105441901

JOHN SHOMAKER & ASSOCIATES, INC.



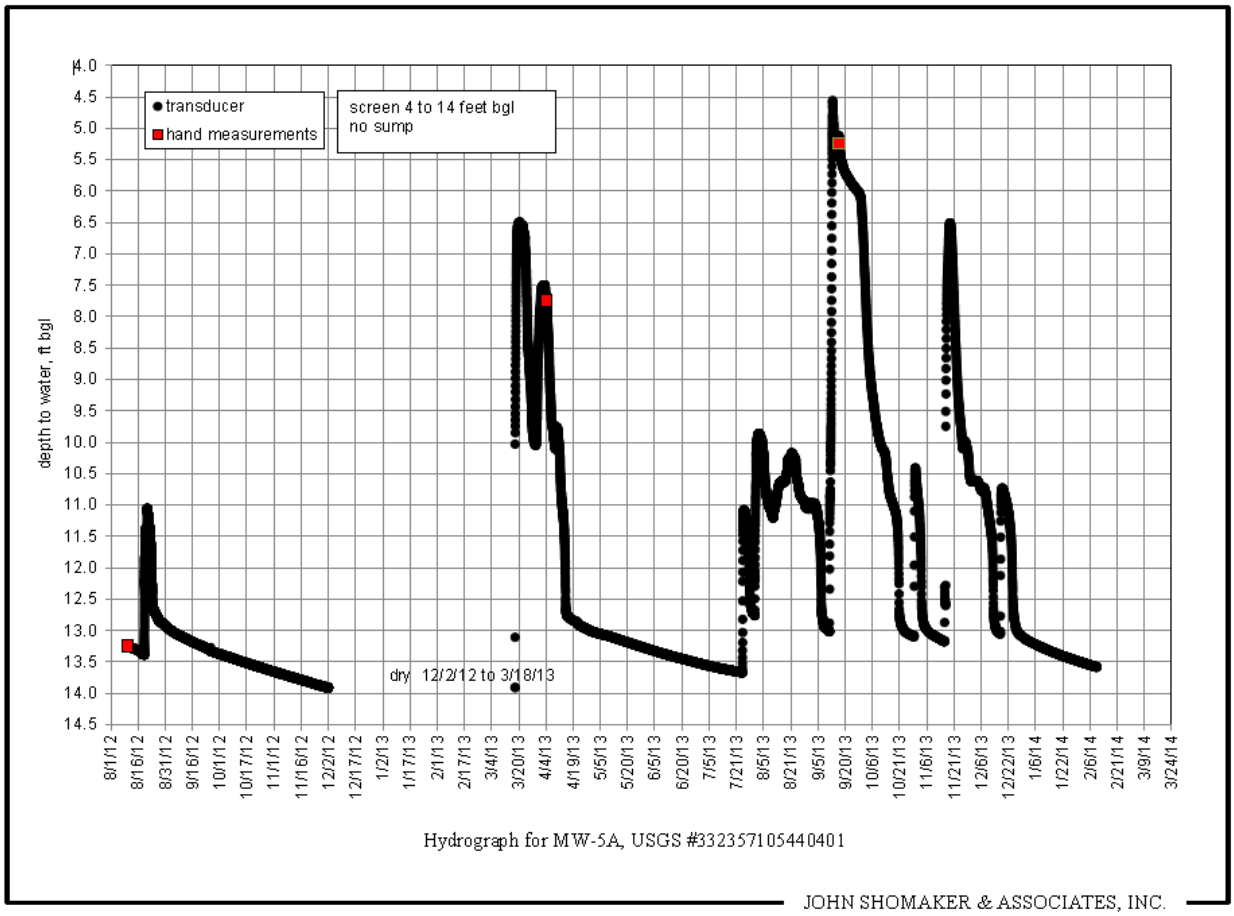
Hydrograph for MW-1C, USGS #332419105441902

JOHN SHOMAKER & ASSOCIATES, INC.

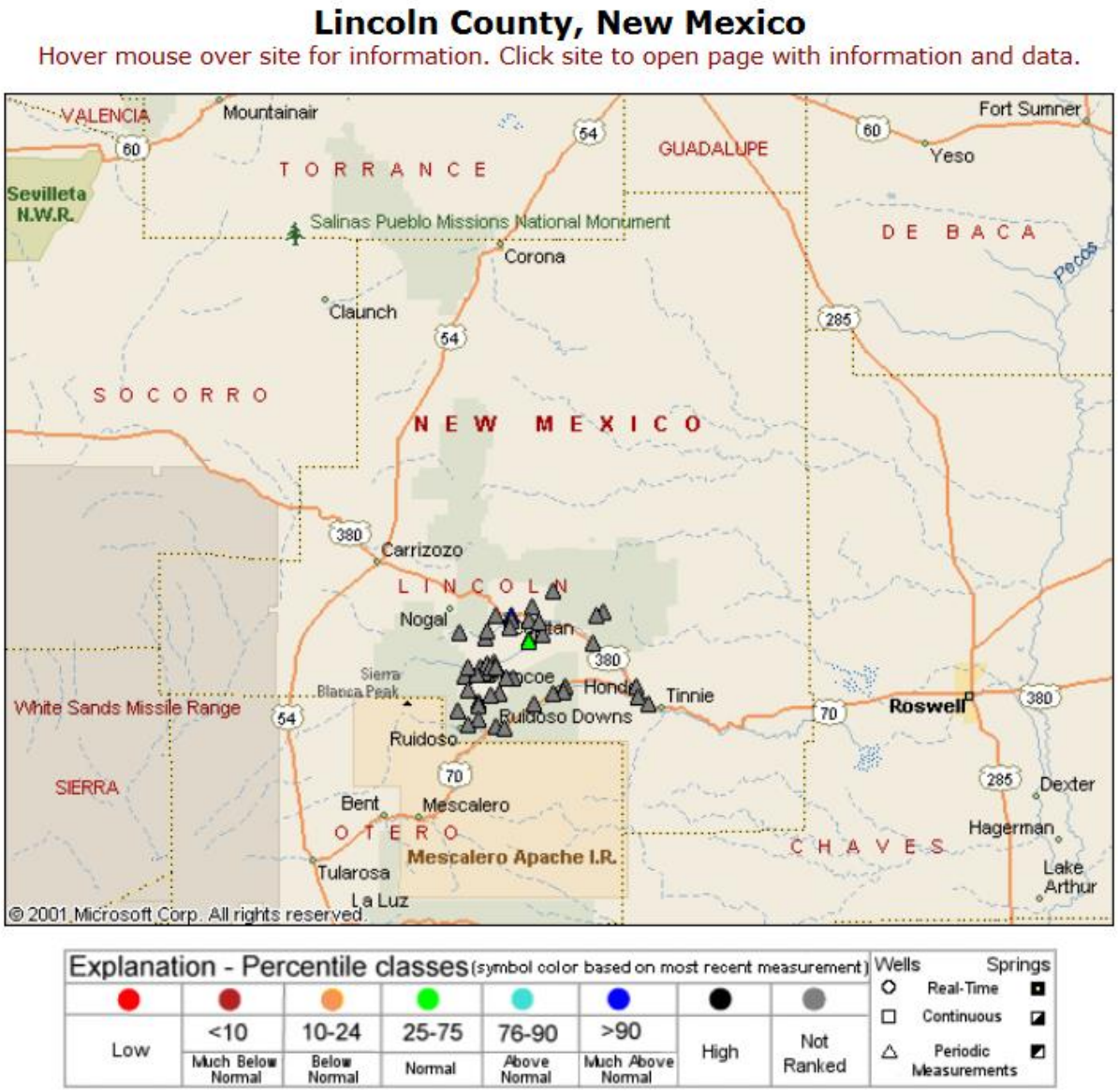


Hydrograph for MW-3A, USGS #332405105441201

JOHN SHOMAKER & ASSOCIATES, INC.

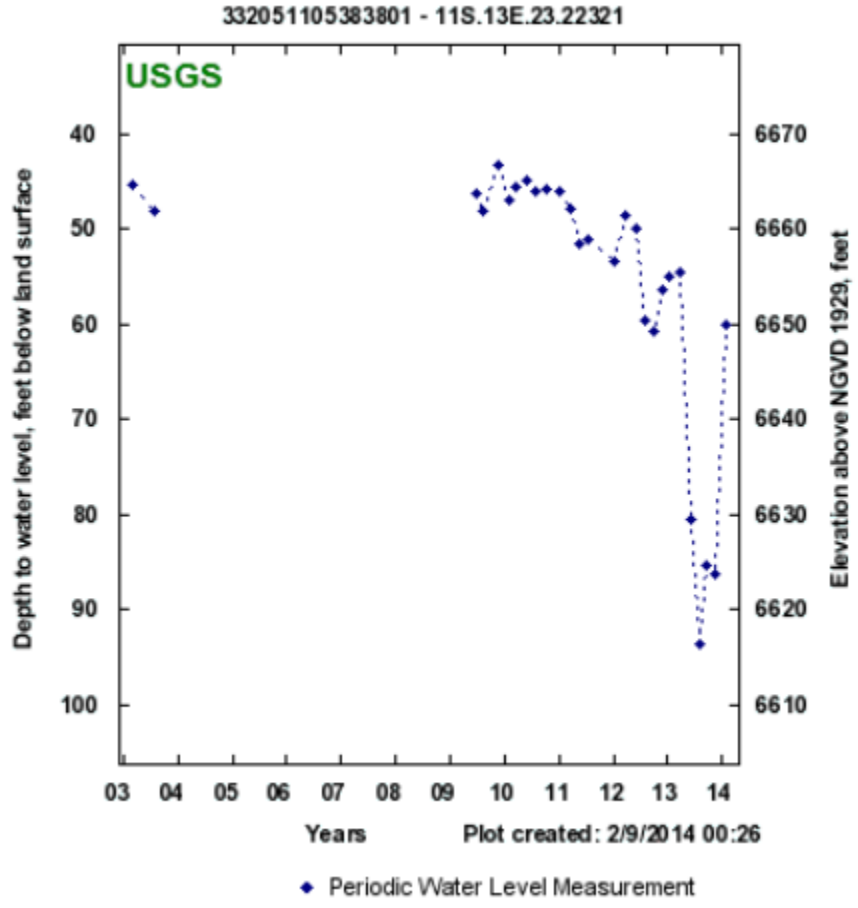

transducer
hand measurements
screen 4 to 14 feet bgl
no sump
depth to water, ft bgl
dry 12/2/12 to 3/18/13
Hydrograph for MW-5A, USGS #332357105440401
JOHN SHOMAKER & ASSOCIATES, INC.

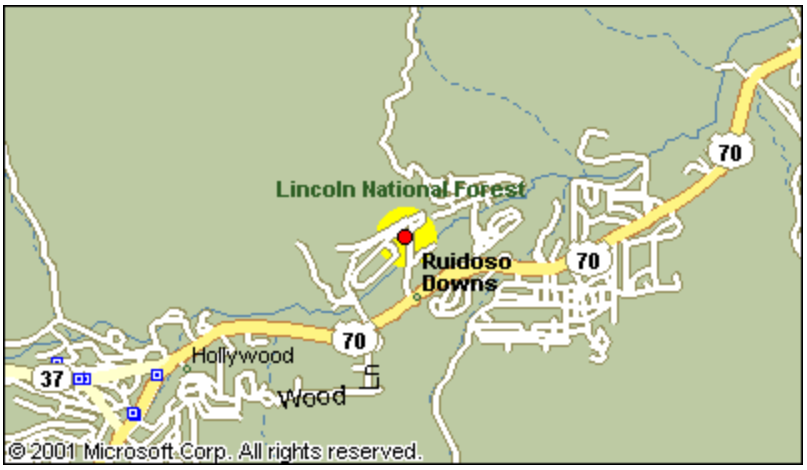
The following hydrographs were downloaded from the USGS (Ground Water Watch) website http://groundwaterwatch.usgs.gov/countymaps/NM_027.html Screenshot below show monitoring stations in Lincoln County.

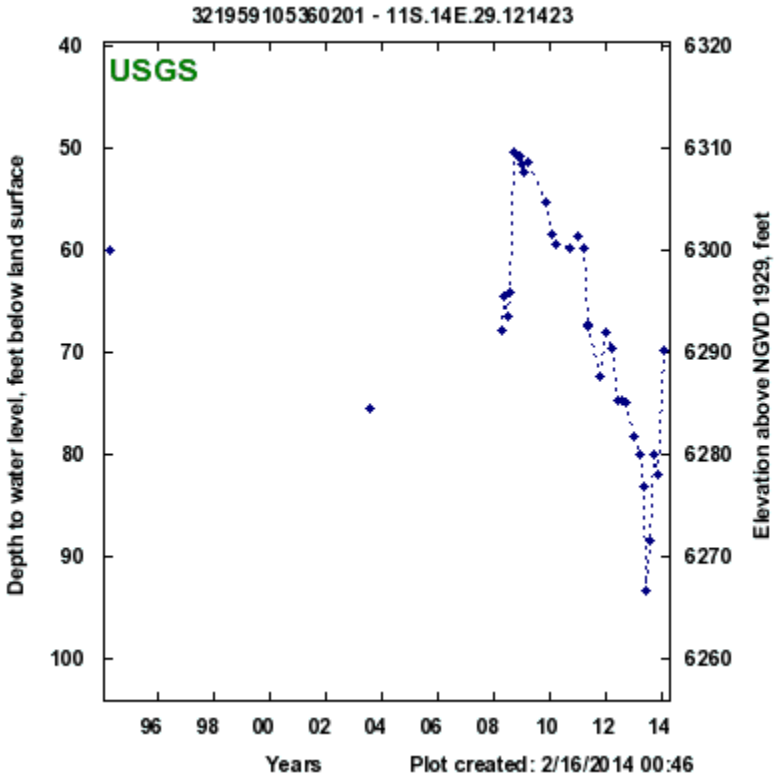


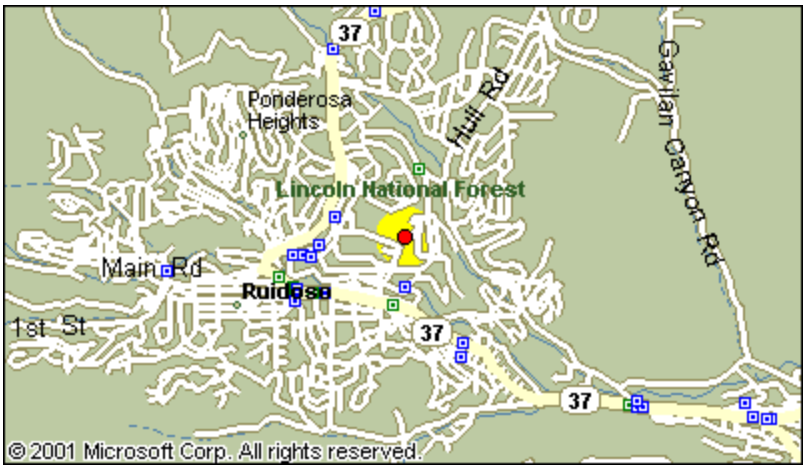
Explanation - Percentile classes (symbol color based on most recent measurement)								Wells / Springs
								Real-Time / Continuous / Periodic Measurements
Low	<10 Much Below Normal	10-24 Below Normal	25-75 Normal	76-90 Above Normal	>90 Much Above Normal	High	Not Ranked	

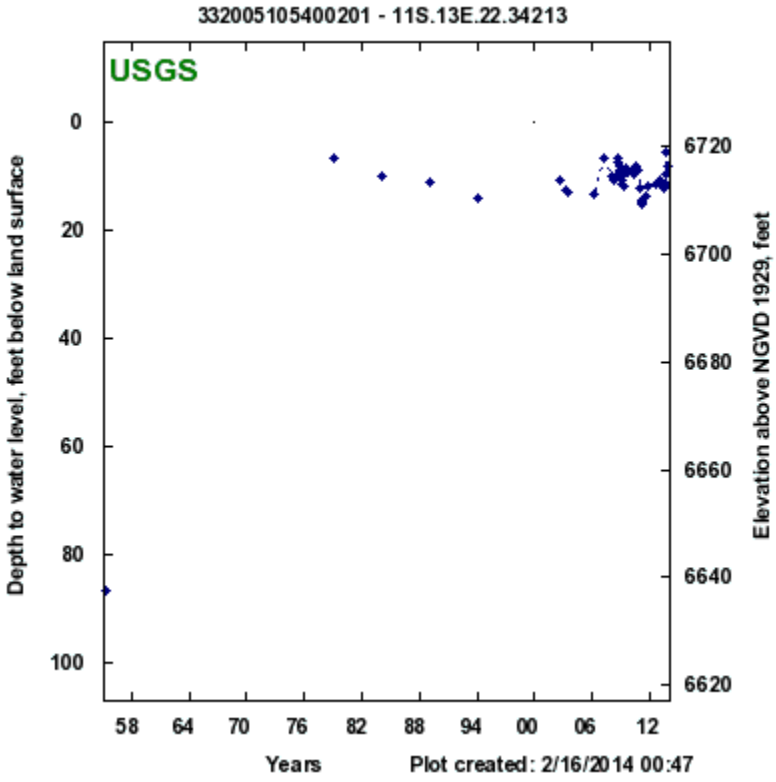

Lincoln National Forest
37
Hull Rd
Hull Rd
Country Club Dr
Garfield Canyon Rd
37
© 2001 Microsoft Corp. All rights reserved.

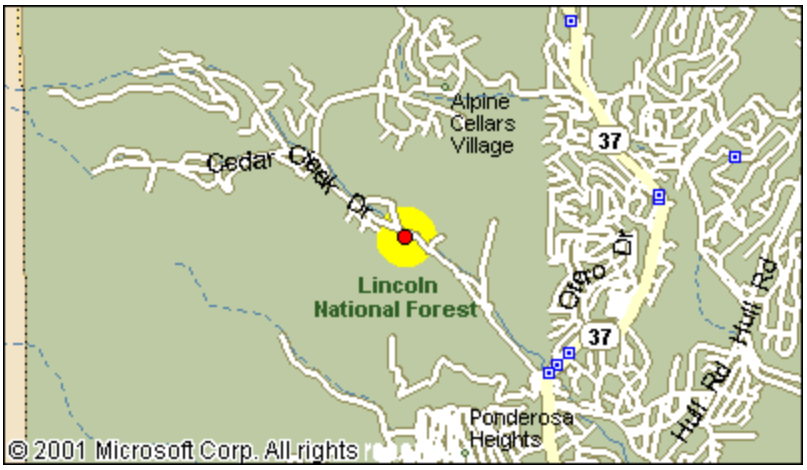

332051105383801 - 11S.13E.23.22321
USGS
Depth to water level, feet below land surface
40
50
60
70
80
90
100
Elevation above NGVD 1929, feet
6670
6660
6650
6640
6630
6620
6610
03
04
05
06
07
08
09
10
11
12
13
14
Years
Plot created: 2/9/2014 00:26
Periodic Water Level Measurement

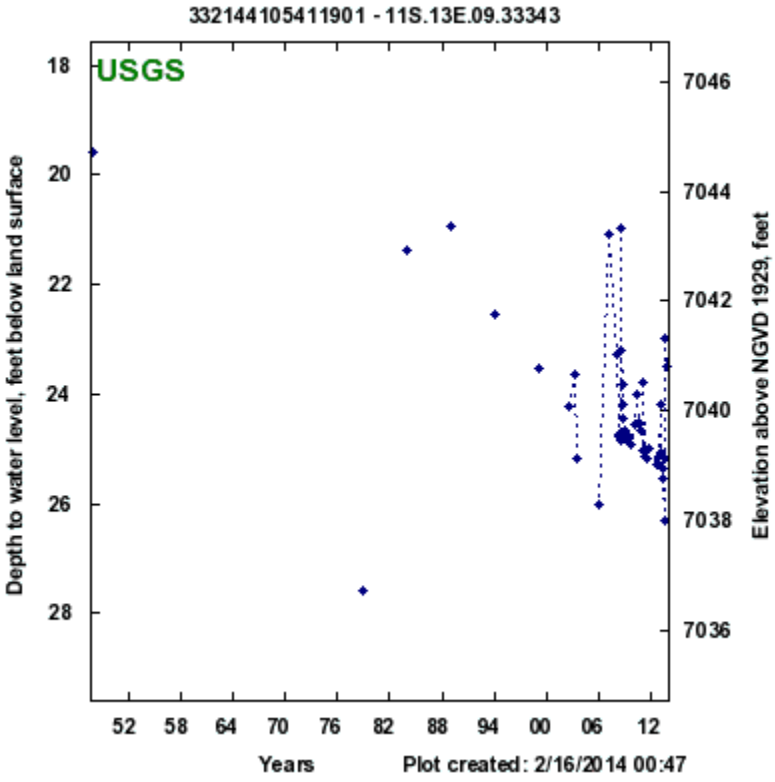

Lincoln National Forest
Ruidoso Downs
70
70
70
Hollywood
37
Wood
Ln
© 2001 Microsoft Corp. All rights reserved.

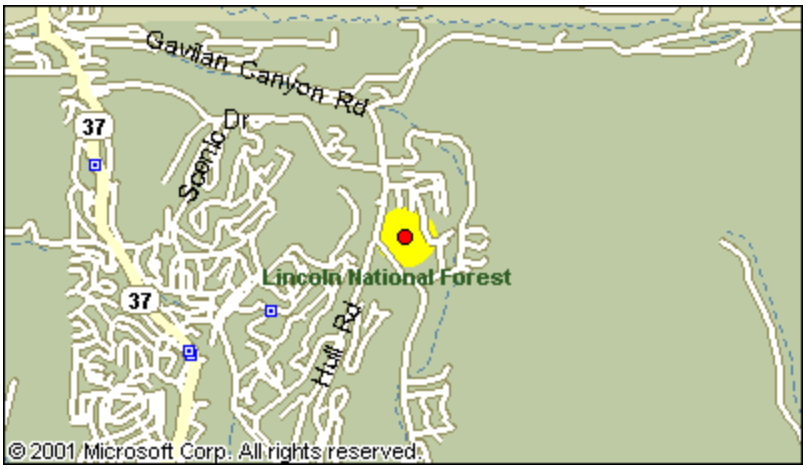

321959105360201 - 11S.14E.29.121423
USGS
Depth to water level, feet below land surface
Elevation above NGVD 1929, feet
40
50
60
70
80
90
100
6320
6310
6300
6290
6280
6270
6260
96
98
00
02
04
06
08
10
12
14
Years
Plot created: 2/16/2014 00:46

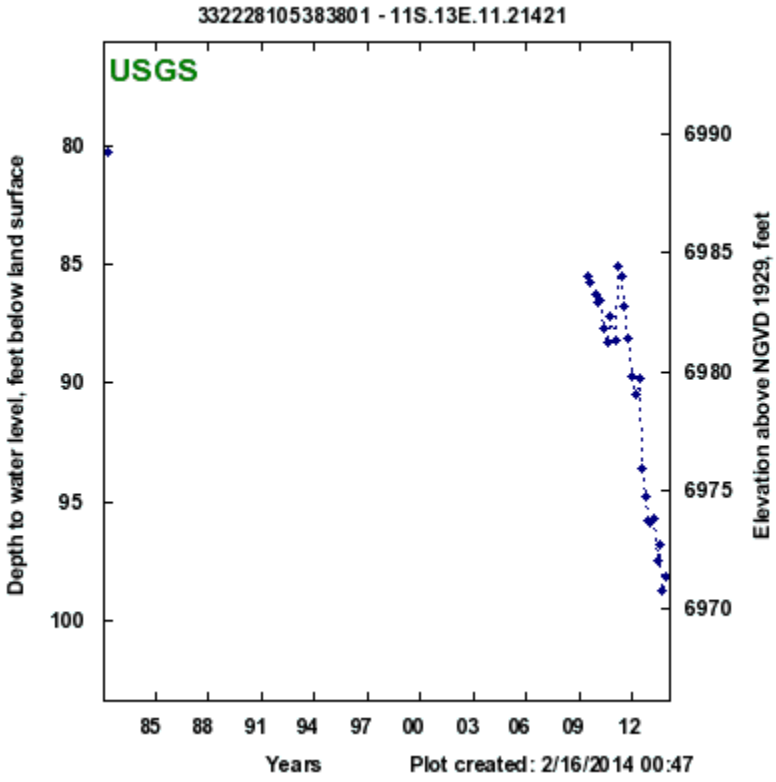

37
Ponderosa
Heights
Hull Rd
Garylan Canyon Rd
Lincoln National Forest
Main Rd
Ruidoso
1st St
37
37
© 2001 Microsoft Corp. All rights reserved.

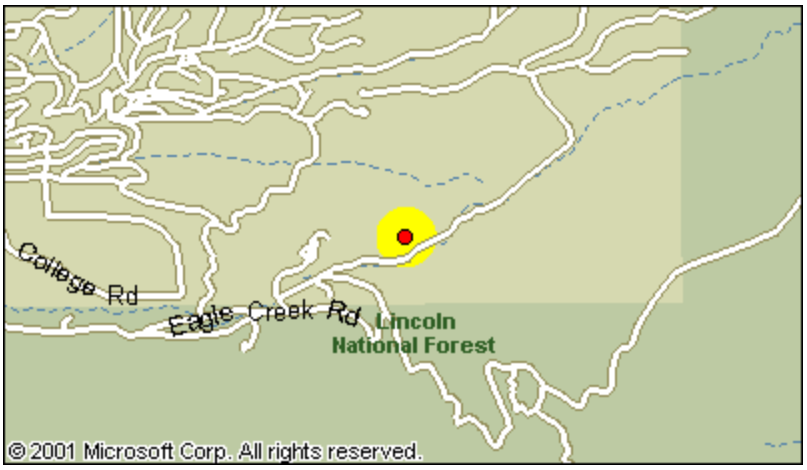

332005105400201 - 11S.13E.22.34213
USGS
Depth to water level, feet below land surface
0
20
40
60
80
100
Elevation above NGVD 1929, feet
6720
6700
6680
6660
6640
6620
58
64
70
76
82
88
94
00
06
12
Years
Plot created: 2/16/2014 00:47

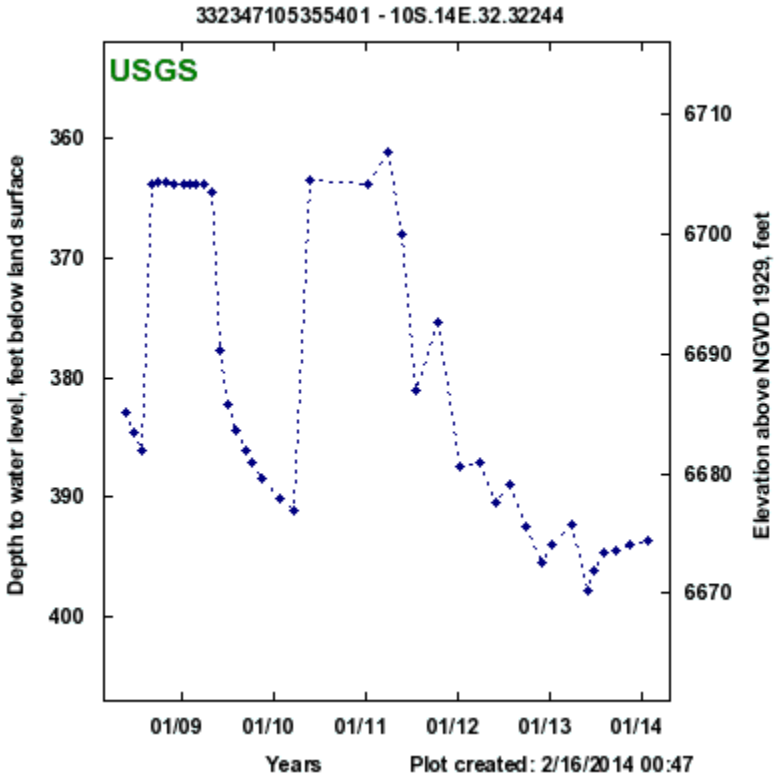

Alpine
Cellars
Village
37
Cedar Creek Dr
Lincoln
National Forest
Cibeo Dr
37
Huff Rd
Huff Rd
Ponderosa
Heights
© 2001 Microsoft Corp. All rights

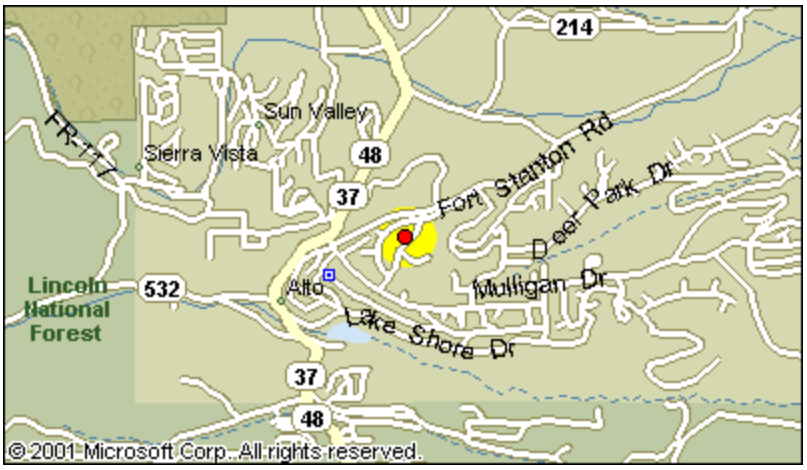

332144105411901 - 11S.13E.09.33343
USGS
Depth to water level, feet below land surface
Elevation above NGVD 1929, feet
18
20
22
24
26
28
7046
7044
7042
7040
7038
7036
52
58
64
70
76
82
88
94
00
06
12
Years
Plot created: 2/16/2014 00:47

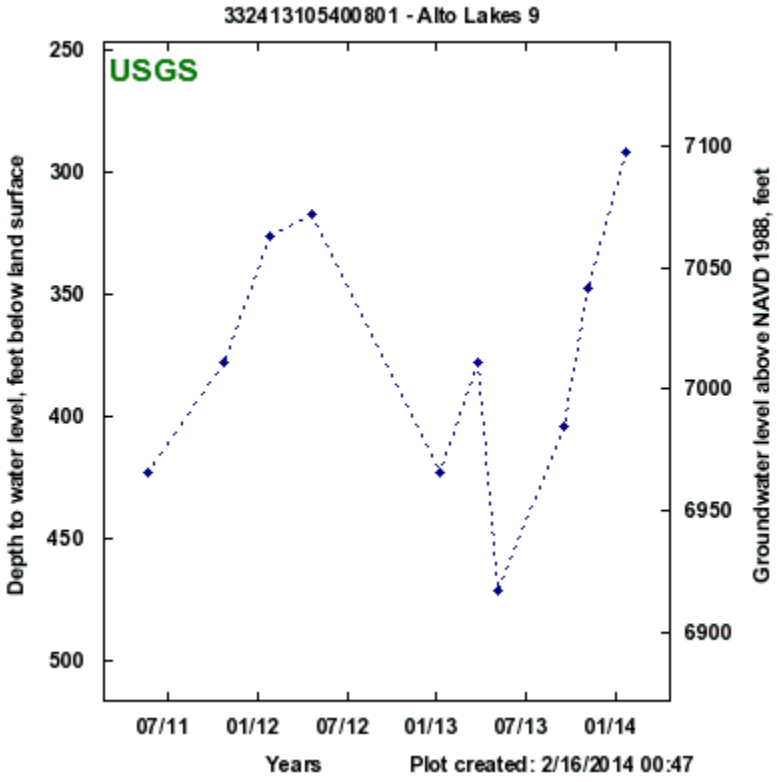

Gavilan Canyon Rd
37
Scenic Dr
Lincoln National Forest
37
Hull Rd
© 2001 Microsoft Corp. All rights reserved.


332228105383801 - 11S.13E.11.21421
USGS
Depth to water level, feet below land surface
80
85
90
95
100
Elevation above NGVD 1929, feet
6990
6985
6980
6975
6970
85
88
91
94
97
00
03
06
09
12
Years
Plot created: 2/16/2014 00:47

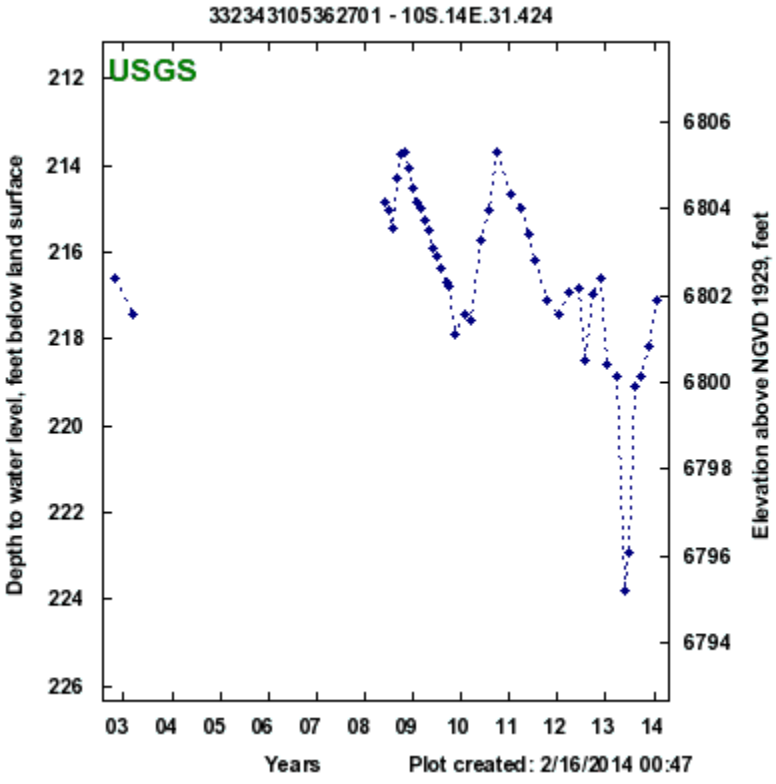

College Rd
Eagle Creek Rd
Lincoln
National Forest
© 2001 Microsoft Corp. All rights reserved.


332347105355401 - 10S.14E.32.32244
USGS
Depth to water level, feet below land surface
360
370
380
390
400
Elevation above NGVD 1929, feet
6710
6700
6690
6680
6670
01/09
01/10
01/11
01/12
01/13
01/14
Years
Plot created: 2/16/2014 00:47


214
Sun Valley
Sierra Vista
48
37
Fort Stanton Rd
Deer Park Dr
Mulligan Dr
Lincoln National Forest
532
Alto
Lake Shore Dr
37
48
© 2001 Microsoft Corp. All rights reserved.


332413105400801 - Alto Lakes 9
USGS
Depth to water level, feet below land surface
250
300
350
400
450
500
Groundwater level above NAVD 1988, feet
7100
7050
7000
6950
6900
07/11
01/12
07/12
01/13
07/13
01/14
Years
Plot created: 2/16/2014 00:47


Sable Rd
High Mesa Rd
College Rd
Eagle Creek Rd
Lincoln National Forest
© 2001 Microsoft Corp. All rights reserved.


332343105362701 - 10S.14E.31.424
USGS
Depth to water level, feet below land surface
Elevation above NGVD 1929, feet
212
214
216
218
220
222
224
226
6806
6804
6802
6800
6798
6796
6794
03
04
05
06
07
08
09
10
11
12
13
14
Years
Plot created: 2/16/2014 00:47